East Coast Railway Infrastructure Protection Projects

Preliminary Option Selection Report

Greystones South to Newcastle

COASTAL CELL AREA 6.1

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Executive Summary

The east coast of Ireland is prone to coastal erosion due to the nature of the geology forming the coastline and the generally low-lying topography between headlands. Along the coast, Iarnród Éireann Irish Rail (IÉ) operates and maintains a safe rail network. The section of railway between Dublin and Wicklow is situated close to the high tide mark, except at Bray Head and Killiney where it is raised up onto, and occasionally tunnelled through, the cliff faces. Disruption to train services caused by storm events and resultant damage to infrastructure is becoming increasingly common; with climate change and related sea level rise expected to be a contributing factor, with disruption predicted to significantly increase in the future. Maintenance works carried out to respond to the effects of coastal erosion and flooding on the railway line and supporting infrastructure result in increasing disruption to existing services and may render the line unviable in this area in the future. If left unattended, there is a risk that the railway route and surrounding land will be lost to the sea.

Recognising the urgency of taking action and the need for a strategic approach, IÉ established the East Coast Railway Infrastructure Protection Projects (ECRIPP). The primary aim of ECRIPP is to provide improved coastal protection works against predicted climate change effects of sea level rise and coastal erosion on the east coast railway corridor between Merrion Gates (Co. Dublin) and Wicklow Harbour (Co. Wicklow). Five key locations along the railway route (known as Coastal Cell Areas (CCAs)) were identified as requiring protection to increase resilience to coastal erosion and coastal flooding as a result of climate change. <u>This document provides the Preliminary Option Selection Report for CCA6.1 - Greystones South to Newcastle (hereafter referred to as "the Project").</u>

This document forms part of the "Phase 2 Concept, Feasibility and Options" stage of the Project. The aim of this report is to investigate coastal protection measures and identify the Emerging Preferred Option and Scheme to manage the main coastal risks. This is for the purposes of ongoing technical and environmental analysis, as well as consultation and engagement with the public and potentially affected property owners.

The Phase 2 stage of the Project comprises option selection, concept design development and public consultation. An options assessment has been carried out to identify the Emerging Preferred Option and the Scheme to be taken forward under the Project. The options assessment was undertaken having regard to the Infrastructure Guidelines and associated guidance.

CCA6.1 is the section of coast that stretches from south of Greystones down to Newcastle. The trainline runs along a natural embankment at the back of the beach. This is a barrier beach feature and is soft; underlain by hard geology. The railway is locally protected by long sections of rock revetment. CCA6.1 also includes the Breaches, an area of land that is reclaimed intertidal land. The main hazards here are wave overtopping (the railway is very low-lying and the beach is generally narrow) and steepening/narrowing of the beach due to long-shore transport. The latter hazard may lead to undermining of the rock structures and the railway itself in the long term. Without intervention, landward erosion of the shoreline would be expected in many locations, The options assessment identified five sub-cells: CCA6.1-A Greystones; CCA6.1-B Cobblers Bulk; CCA6.1-C Kilcoole; CCA6.1-D Cooldross; and CCA6.1-E Newcastle North (See Figure ES below).

The vulnerability of the sub-cells to different hazard scenarios varies, but in general:

- The risk of wave overtopping, toe scour and structural failure is higher at Cobblers Bulk and Kilcoole where the beach is narrower and the railway is closer to the shore.
- There is a long term erosional trend at Cobblers Bulk and Kilcoole where the beaches are currently narrower and suffer from more seasonal and storm variation. These are the locations where losses of beach material will expose the defences, slopes and low shoreline cliffs to the other failure modes.
- Low-lying soft cliffed backshores are located across most of CCA6.1. Risk varies according to beach size and distance of the railway from the shoreline.

The initial step of the optioneering assessment identified the Long List of Options comprising a range of interventions and measures that could be used to provide a long-term approach to manage the coastal erosion and coastal flooding risks to the railway line (inclusive of predicted climate change impacts). Through a process of option screening a Short List of Options was identified comprising those options that are likely to be technically feasible.

The Short List of Options passed through to the Multi-Criteria Assessment (MCA) stage where the key risks, opportunities, advantages and disadvantages of the short list options were identified. The MCA identified the leading options as follows (See Figure ES below):

- **Option A**: comprises rock revetments and wave walls for the full coastal cell. These revetments will vary in form along the frontage relative to the wave exposure, foreshore type/level and to integrate with the various natural and man-made shoreline features.
- **Option B**: comprises rock revetments and wave walls for Cobblers Bulk (CCA6.1-B), Kilcoole (CCA6.1-C) and Newcastle North (CCA6.1-E). No works are proposed until 2055 at Greystones (CCA6.1-A) and Cooldross (CCA6.1-D). The deferred option at Greystones comprises localised rock revetment, and beach nourishment if required in the northern section of the sub-cell. At Cooldross the deferred option comprises a rock berm in front of the existing vegetated beach, combined with a flood wall seaward of the railway line boundary. This option acknowledges that at Cooldross the existing beach is relatively healthy, and the railway line is setback further from the crest of the beach.

These options all meet the scheme objectives, the requirements for the minimum 50-year design life and no maintenance for 25 years and provide the required standard of protection. The options all adopt a "Hold the Line" approach by protecting the shoreline on its current alignment using upgraded defences to improve the standard of protection. These options were progressed to Concept Design level and have been modelled and costed. The output of this analysis combined with the MCA has **identified the Emerging Preferred Option (EPO) as Option A**.

The next stage of the optioneering assessment identifies the works to be delivered under the Project (the Scheme). The works for the Emerging Preferred Option (EPO) within each sub-cell of the CCA were prioritised based on the current vulnerability of the railway to coastal hazards. The Implementation Options (IOs) consider the timeframe for implementing works based on hazards changing in line with climate change impacts. IOs were developed for the CCA, identifying options for prioritising works to align with increasing coastal hazard and risk to the railway. The IOs considered are as follows:

- **IO1**: delivers the EPO Option A works under ECRIPP to protect to 2100 regardless of whether works are needed now. The exception is that no works are proposed at Cobblers Bulk (CCA6.1-B) and Kilcoole (CCA6.1-C) where there are existing revetments. Works comprises rock and concrete revetments through Greystones (CCA6.1-A), Cooldross (CCA6.1-D) and Newcastle North (CCA6.1-E). Concrete flood walls are required in most areas where revetments are proposed.
- **IO2**: delivers some of the EPO Option A works under ECRIPP to protect to 2075 and defers some works into the longer term until they are needed. As per IO1, no works are proposed at Cobblers Bulk (CCA6.1-B) and Kilcoole (CCA6.1-C) where there are existing revetments. Works are as per IO1, but with works close to Greystones (CCA6.1-A) and some works in Cooldross (CCA6.1-D) deferred.
- **IO3**: delivers parts of EPO Option A under ECRIPP needed by 2050 and defers works into the longer term until they are needed. All works at Greystones (CCA6.1-A) and further works at Cooldross (CCA6.1-D) and Newcastle North (CCA6.1-E) are deferred. Works comprise rock and concrete revetments in remaining parts of Cooldross (CCA6.1-D) and Newcastle North (CCA6.1-E) and associated floodwalls (where needed).
- **IO4**: deliver highest priority works only under ECRIPP and defers all other works. Works are as per IO3, but further works are deferred in parts of Newcastle North (CCA6.1-E).
- **IO5**: Do Minimum – do not progress any of the works under the EPO but undertake reactive works as needed.

These options were assessed using MCA to identify the Emerging Preferred Scheme (EPS) to be delivered under the Project and develop the corresponding concept designs. The MCA has **identified the Emerging Preferred Scheme (EPS) as Implementation Option 3 (IO3)**, comprising:

- Rock revetments in parts of Cooldross (CCA6.1-D) and Newcastle North (CCA6.1-E).
- Concrete revetments in small sections of Cooldross (CCA6.1-D) and Newcastle North (CCA6.1-E) around The Breaches.
- Reinforced concrete floodwalls through much of Newcastle North (CCA6.1-E) (See Figure ES below).

The Emerging Preferred Scheme will deliver a minimum of 50 years (2075) protection to the railway line against coastal erosion hazards at locations where the railway line would be at risk in the next 25 years (2050) if no capital works were undertaken. The capital works delivered under this Project will form part of the longer term works likely needed to extend the protection of the railway line to 2100.This Preliminary Option Selection Report (POSR) identifying the Emerging Preferred Scheme (EPS) is a key document that is presented through the stakeholder engagement and public consultation process. Comments and feedback received during Public Consultation 1 (PC1) will be used to prepare the Option Selection Report (OSR), which will identify the Preferred Scheme to be taken forward to the "Phase 3 Preliminary Design" stage of the Project.

Preliminary design will develop the Phase 2 Concept Designs to provide increased certainty on the structure geometry and detailing. This stage of design will consider in more detail the interfaces with the existing structures through the development of a 3D design. Further work will be undertaken to consider how the works will be constructed and how construction impacts can be avoided or mitigated.

The Preliminary Design Report will be presented for further public consultation and feedback which feeds into the Reference Design and culminates with statutory consultation as part of statutory consent applications.

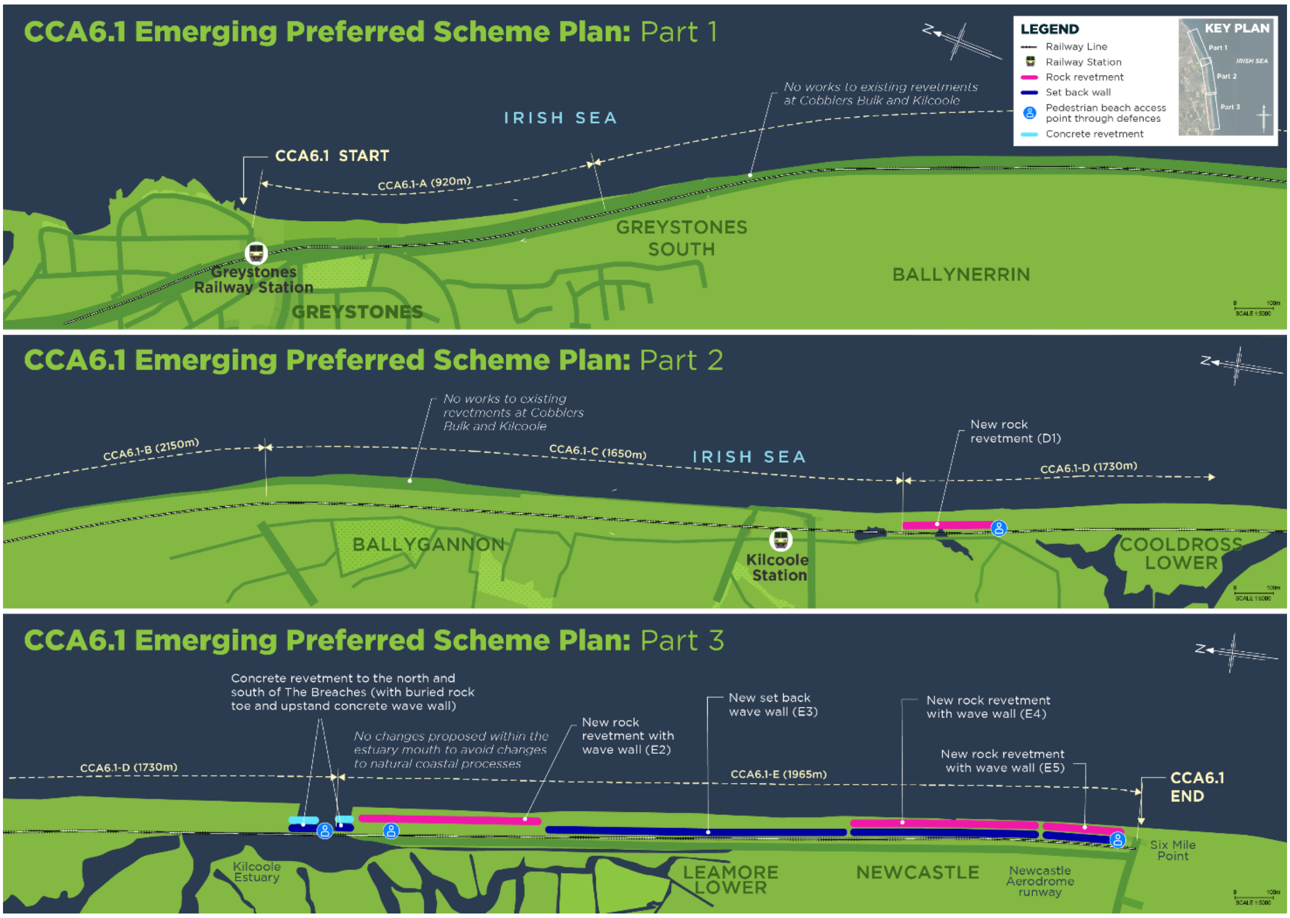

Figure ES: CCA6.1 Emerging Preferred Scheme Plan

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Acronyms and Abbreviations

AA	Appropriate Assessment
ACA	Architectural Conservation Area
APIS	Authorisation for Placing in Service
CAF	Common Appraisal Framework
CCAs	Coastal Cell Areas
CFRAM	Catchment Flood Risk Assessment and Management
DCC	Dublin City Council
DEFRA	Department for Environment, Food and Rural Affairs
DLR	Dún Laoghaire Rathdown
DTTAS	Department of Transport Tourism and Sport
ECRIPP	East Coast Railway Infrastructure Protection Projects
EMRA	Eastern & Midlands Region Assembly
EPO	Emerging Preferred Option
EPS	Emerging Preferred Scheme
GDA	Greater Dublin Area
GDATS	Greater Dublin Area Transport Strategy
GHG	Green House Gas
HSE	Health, Safety and Environment
IÉ	Iarnród Éireann
IROPI	Imperative Reasons of Overriding Public Interest
LL	Long List
MAC	Marine Area Consent
MARA	Maritime Area Regulatory Authority
MCA	Multi-Criteria Assessment
MDC	Multi-disciplinary Consultant
MSO	Marine Survey Office
NDP	National Development Plan
NMPF	National Marine Planning Framework
NPF	National Planning Framework
NPO	National Policy Objective
NPWS	National Parks and Wildlife Services
NSO	National Strategic Outcomes

NTA	National Transport Authority
OPW	Office of Public Works
PC	Public Consultation
pNHAs	Proposed Natural Heritage Areas
RIBA	Royal Institute of British Architects
RPO	Regional Policy Objectives
RPS	Record of Protected Structures
RSES	Regional Spatial and Economic Strategy
RSO	Regional Strategic Outcomes
SAC	Special Areas of Conservation
SMR	Sites and Monuments Record
SoP	Standard of Protection
SPA	Special Protection Area
TAF	Transport Appraisal Framework
UN SDGs	United Nations Sustainable Development Goals
VAT	Value Added Tax
WFD	Water Framework Directive

1. Introduction

1.1 Projects Overview

Iarnród Éireann Irish Rail (IÉ) operates and maintains a safe rail network on the east coast of Ireland. The Dublin to Wicklow section of this line is a critical part of the rail network, with southside DART, Gorey commuter and Rosslare Europort Intercity services operating along this scenic route.

The railway is situated along the coast close to the high tide mark, except at Bray Head and Killiney where it is raised up onto, and occasionally tunnelled through, the cliff faces. The east coast of Ireland is prone to coastal erosion due to the nature of the unconsolidated glacial till forming the coastline and cliffs as well as the generally low-lying topography between headlands. This has been demonstrated through a number of technical studies over the years carried out by IÉ, the Office of Public Works and the affected County Councils.

Since the railway was opened to Greystones and extended to Wicklow and Rosslare in the mid-1800's there have been many cases of disruption to train services caused by storm events and resultant damage to infrastructure. IÉ records indicate that these incidents are becoming increasingly common and climate change and related rise in sea levels is thought to be a key factor. This necessitates more maintenance works to be carried out to respond to the effects of coastal erosion, wave overtopping and coastal flooding on the rail line and supporting infrastructure. These works result in increasing disruption to existing services and may render the line unviable in this area in the future as more significant climate change impacts become realised. If left unattended, there is a risk that the railway route and surrounding land will be lost to the sea and this risk will increase in line with climate change impacts, particularly sea level rise and increased storminess.

In 2017, IÉ undertook a feasibility study to assess the anticipated increase in maintenance requirements for this area resulting from climate change. This study identified several key areas between Dublin and Wicklow where strategic intervention at this time would enable existing rail services to continue to operate safely with minimal disruption.

Recognising the urgency of taking action and the need for a strategic approach, IÉ established the East Coast Railway Infrastructure Protection Projects (ECRIPP). ECRIPP will be delivered in line with National Transport Authority Project Approval Guidelines. The primary aim of ECRIPP can be summarised as follows:

"Provide improved coastal protection works against predicted climate change effects of sea level rise and coastal erosion on the east coast railway corridor between Merrion Gates (Co. Dublin) and Wicklow Harbour (Co Wicklow)".

Previous studies by IÉ and others identified five key locations along the 65km route running parallel to the Dublin to Rosslare railway line as requiring protection to increase resilience to coastal erosion and coastal flooding as a result of climate change. These coastal cell areas have been assessed as they have experienced incursions to such levels that existing infrastructure is at risk due to coastal erosion and/or flooding.

Under ECRIPP, the five sites or Coastal Cell Areas (CCAs) are considered as separate projects for delivery (Figure 1-1). They are listed below:

- CCA1 Merrion to Dún Laoghaire.
- CC2-3 Dalkey Tunnel to Shanganagh Bray Wastewater Treatment Plant.
- CCA5 Bray Head to Greystones North Beach.
- CCA6.1 Greystones South to Newcastle; and
- CCA6.2 Newcastle to Wicklow Harbour.

This report covers CCA6.1 (see Figure 1-2), an 8.5km length of coastline from Greystones South to Newcastle (hereafter referred to as "the Project").

Figure 1-1 Location of Coastal Cell Areas

Figure 1-2 Overview of CCA6.1

1.2 Project Objectives

The primary focus of this Project is to address and implement protection of the existing railway and coastal infrastructure against the further effects of coastal erosion and flooding due to climate change on the strategically important railway line between Greystones South and Newcastle.

The key objectives of the Project include:

- support the continued safe operation of rail services;
- increase railway infrastructure future resilience to climate change;
- provide improved and sustainable coastal protection works against predicted climate change effects such as sea level rise, coastal erosion and storm surges on the east coast railway corridor;
- secure the railway line for future generations;
- allow for the long-term efficient management and maintenance of the railway corridor; and
- support sustainable low carbon local, regional and international connectivity fostering a low carbon and climate resilient society.

The design objectives of the Project include:

- Provides the required 50 year design life (minimum). This is the service life intended by the design, which is the period of time after installation during which the structure meets or exceeds the structural performance requirements;
- Provides the required 25 years of zero heavy maintenance;
- Provides the required Standard of Protection (SoP) for the railway. The SoP is defined as a 1 in 200 year storm protection level; and
- Identifies the longer term works likely needed to extend the protection of the railway line to 2100.

1.3 Report Purpose

This document provides the Preliminary Option Selection Report for CCA6.1 – Greystones South to Newcastle, which sits under the "Phase 2 Concept Feasibility and Options" stage of the Project.

This report sets out the process undertaken to assess the alternative protection measures for the selection of the capital works delivered under this Project, and identification of the longer term works likely needed to extend the protection of the railway line. This report should be read in full in conjunction with associated appendices.

1.3.1 Status of the Design Presented in this Report

This report presents the Emerging Preferred Scheme for the purposes of ongoing technical and environmental analysis, as well as consultation and engagement with the public and potentially affected property owners. In this regard, the Emerging Preferred Scheme will continue to be analysed and recalibrated based on public consultation feedback. This ongoing work will inform the 'Preferred Scheme' which will be published as part of Public Consultation 2 (PC2) when additional surveys and assessments have been completed. The information presented to the public and stakeholders as part of Public Consultation 1 (PC1) is a current snapshot of available information and design development.

The purpose of presenting this Preliminary Option Selection Report is to communicate the current status of the option selection process, the methodology being followed to identify the Emerging Preferred Scheme and to assist in obtaining feedback. As part of the public consultation process, stakeholders, including the public, will be invited to make observations on the Emerging Preferred Scheme for consideration by the Project Team.

1.4 Report Structure

The structure of the remainder of this report is set out as follows:

- Chapter 2: Planning and Policy Context – This chapter outlines the general background information to the Project and summarises the planning and policy context which is relevant to the option selection process.
- Chapter 3: Options Assessment Methodology – This chapter outlines the stepped approach for the options assessment process.
- Chapter 4: Study Area and Problem Definition – This chapter describes the study area, the CCA sub-cells and the hazard scenarios that adversely affect operation of the railway. This includes an assessment of the consequence of hazards and vulnerability of assets to document the risk.
- Chapter 5: Options Assessment – This chapter provides the options assessment results for the CCA, from long list solutions, to developing short list options through Multi Criteria Analysis, to the Emerging Preferred Option and the selection of the Emerging Preferred Scheme.
- Chapter 6: Stakeholder Consultation – This chapter outlines the summary of the non-statutory public consultation and key stakeholder consultation completed to date.
- Chapter 7: Emerging Preferred Scheme – This chapter describes the Emerging Preferred Scheme proposal.

2. Planning and Policy Context

This chapter summarises the relevant planning policy and guidance both for the land-based areas and the marine elements of the Project which are applicable to the options selection process for CCA6.1. Further detail on planning and policy context can be found in Appendix A Planning and Environmental Constraints Report.

2.1 Land Based Areas

2.1.1 National Policy / Guidance

2.1.1.1 Project Ireland 2040

This Project falls within the remit of Project Ireland 2040. The National Planning Framework (NPF) which was adopted in May 2018 sets out the Government's Strategic Framework to guide development and investment. The NPF pairs with the National Development Plan (NDP) to comprise Project Ireland 2040. The NDP was originally published in 2018 for the period 2018-2027 but this has been reviewed and re-published for the period 2021-2030.

2.1.1.1.1 National Development Plan (NDP) 2021 - 2030

Within the NDP, National Strategic Outcomes (NSO) 2 'Enhanced Regional Accessibility' is of particular relevance to the Project. A key part of this outcome is the protection of public transport infrastructure.

Further detail on the objectives outlined in the NDP can be found in Appendix A.

2.1.1.1.2 National Planning Framework (NPF) 2018 – 2030

National Policy Objectives (NPO's) outlined within the NPF that are of relevance to the proposed Project are NPO 40, NPO 41a and NPO 41b. The referenced NPOs seek to ensure the strategic development of ports, sustainable development of city regions and regional/rural areas, ensure effective management of Irelands coastal resource and address the effects of sea level changes, coastal flooding and erosion.

Further detail on the objectives outlined in the NPF can be found in Appendix A.

2.1.1.2 Transport Climate Change Sectoral Adaptation Plan 2019

The Transport Climate Change Sectoral Adaptation Plan 2019 recognises the risk of climate change impact on the Irish transport sector and its infrastructure. The plan sets out adaptation measures to protect the transport sector. The plan references the Eastern Rail Corridor, of which a section includes the proposed Project, as a case study to show the coastal erosion impacts already incurred in this region.

The Plan has an overarching adaptation goal which is to "*ensure that the sector can fulfil its continuing economic, social and environmental objectives by ensuring that transport infrastructure is safeguarded from the impacts of climate change.*"

Further detail on the plan can be found in Appendix A.

2.1.2 Coastal Change Management Strategy

The Coastal Change Management Strategy was published by the OPW in 2023 to provide a roadmap for responding to coastal change management in a structured and planned way to provide the basis for a long term strategy for an integrated and coordinated approach to coastal change management.

It includes a range of policy related to communication, data and research related to numerous matter including coastal change management plans, rick management, sustainable management of the coastline, the need for high quality data to support decision making and the importance of research.

Appendix A sets out those policy's/approached of particular relevance to the Project.

2.1.3 Regional Policy / Guidance

2.1.3.1 Regional Spatial and Economic Strategy (RSES) 2019-2031

2.1.3.1.1 Eastern & Midlands Region RSES

This Project falls into the remit of the Eastern & Midlands Regional Assembly (EMRA). The EMRA RSES outline a number of Regional Strategic Outcomes (RSO's) and Regional Policy Objectives (RPO's) that relate to the Project.

An overall objective of the EMRA RSES is to protect and enhance strategic connections which includes the Eastern Corridor (rail link to Rosslare Europort). This strategic connection is identified as a key growth enabler for the region. Objectives that are of importance to the Project are outlined in Appendix A.

2.1.3.1.2 Southern Region RSES

Whilst the Project does not fall within this geographical area, the proposed Project connection to Rosslare Europort and the population along the east coast are of relevance. Wexford town is identified as a key town in the Southern Region RSES and it has a number of objectives that are of importance to the Project which are outlined in Appendix A.

2.1.3.2 Greater Dublin Area Transport Strategy 2022 – 2042

The Project falls within the remit of the Greater Dublin Area Transport Strategy (GDATS) 2022 – 2042. The GDATS outlines a number of policy objectives to support the proposed Projects through climate change proofing existing public infrastructure, enhancement of sustainable transport provision and improving connectivity within the Greater Dublin Area (GDA). Appendix A provides an overview of the GDATS 2022-2042.

2.1.4 Local Policy / Guidance

2.1.4.1 Wicklow County Council

The Wicklow County Development Plan 2022 – 2028 was adopted on the 12th September 2022 and came into effect on the 23rd of October 2022.

CCA6.1 is located entirely within the functional area of Wicklow County Council (WCC). The Plan sets out a strategic spatial planning framework for guiding the physical, economic and social development of the County. The land use zonings of the key areas are not set out as part of the Plan, these areas and the map-based objectives are set out within the specific Local Area Plans (LAP); these plans are to be read in conjunction with the County Development Plan. Not all of the ARUPs defined works areas are within zoned lands.

2.1.4.1.1 Greystones Delgany and Kilcoole LAP 2013 – 2019

Following an amalgamation of LAP's the Greystones Delgany and Kilcoole LAP was adopted in 2013. CCA6.1 extends within the Greystones Delgany and Kilcoole LAP approximately from North Shore Road to South of Kilcoole.

Action Plan 4 (South Beach), the objective of which is, as follows:

"Development of lands as an extension to the established town centre with a mix of retail, offices and public buildings, with residential uses interspersed to command public spaces and the South Beach. Provision of active frontage to Mill Road. maximize views from the development of the coast and sea. Improvements to the security and amenity of pedestrian access to South Beach. Provision of the majority of car-parking in underground or part underground, under podium or multi-storey format. ƒ Provision of a 'park-and-ride' site of an appropriate scale. Any development proposal shall include a public playground and outdoor adult gymnasium, of appropriate size, in consultation with the Community and Enterprise Section of the Council. These facilities shall be located within reasonable access of South Beach."

2.1.4.1.2 Wicklow Climate Action Plan

The Wicklow Climate Action Plan 2024 – 2029 was launched on the 21 December 2023. The plan is split into eight key goals categorised under five thematic areas: Governance and leadership, Built Environment and Transport, Natural Environment and Green Infrastructure, Communities Resilience and Transition and Sustainability and Resource Management.

The key targets and principles of importance to the Project are set out in Appendix A.

2.2 Marine Elements

2.2.1 National Marine Planning Framework (NMPF) 2040

The NMPF was published in July 2021 and is intended as the marine equivalent to the National Planning Framework (NPF). It provides the following in regard to the marine area:

- *"set a clear direction for managing our seas;*
- *clarify objectives and priorities; and*
- *direct decision makers, users and stakeholders towards strategic, plan-led, and efficient use of our marine resources."*

In regard to coastal erosion and flood defence works it sets out the following under Climate Change Policy 1:

"*Proposals should demonstrate how they:*

- *avoid contribution to adverse changes to physical features of the coast;*
- *enhance, restore or recreate habitats that provide a flood defence or carbon sequestration ecosystem services where possible.*

Where potential significant adverse impacts upon habitats that provide a flood defence or carbon sequestration ecosystem services are identified, these must be in order of preference and in accordance with legal requirements, be:

a) avoided,

b) minimised,

c) mitigated,

d) if it is not possible to mitigate significant adverse impacts, the reasons for proceeding must be set out.

This policy should be included as part of statutory environmental assessments where such assessments are required."

In addition to the above and again in regard to coastal erosion and flood defence, the NMPF acknowledges that the Office for Public Works (OPW) "*have functions and responsibilities in relation to coastal protection and coastal flooding*." It continues to outline the OPWs role, as follows:

- *"Undertaking risk assessments associated with coastal flooding and coastal erosion at selected coastal sites making use of innovative technologies and methodologies;*
- *Provision of an advisory service in relation to coastal flooding and coastal erosion to support the preparation of annual coastal protection funding programmes, the Catchment Flood Risk Assessment and Management (CFRAM) programme, and to inform broader policy development; and*
- *Maintenance of coastal protection schemes constructed under the Coast Protection Act, 1963."*

As well as general guidance for marine development the NMPF also includes Marine Map Based Objectives and Marine Spatially specific policy objectives. Appendix A incudes at Table 1-1 and 1-2 NMPF Marine Map Based Objectives (MMBOs) and Marine Spatially Specific Policy Objectives (SSPOs) relevant to CCA 6.1.

3. Options Assessment Methodology

3.1 Introduction

This chapter sets out the methodology followed in undertaking the options assessment and the selection of the Emerging Preferred Scheme for the Phase 2 optioneering process.

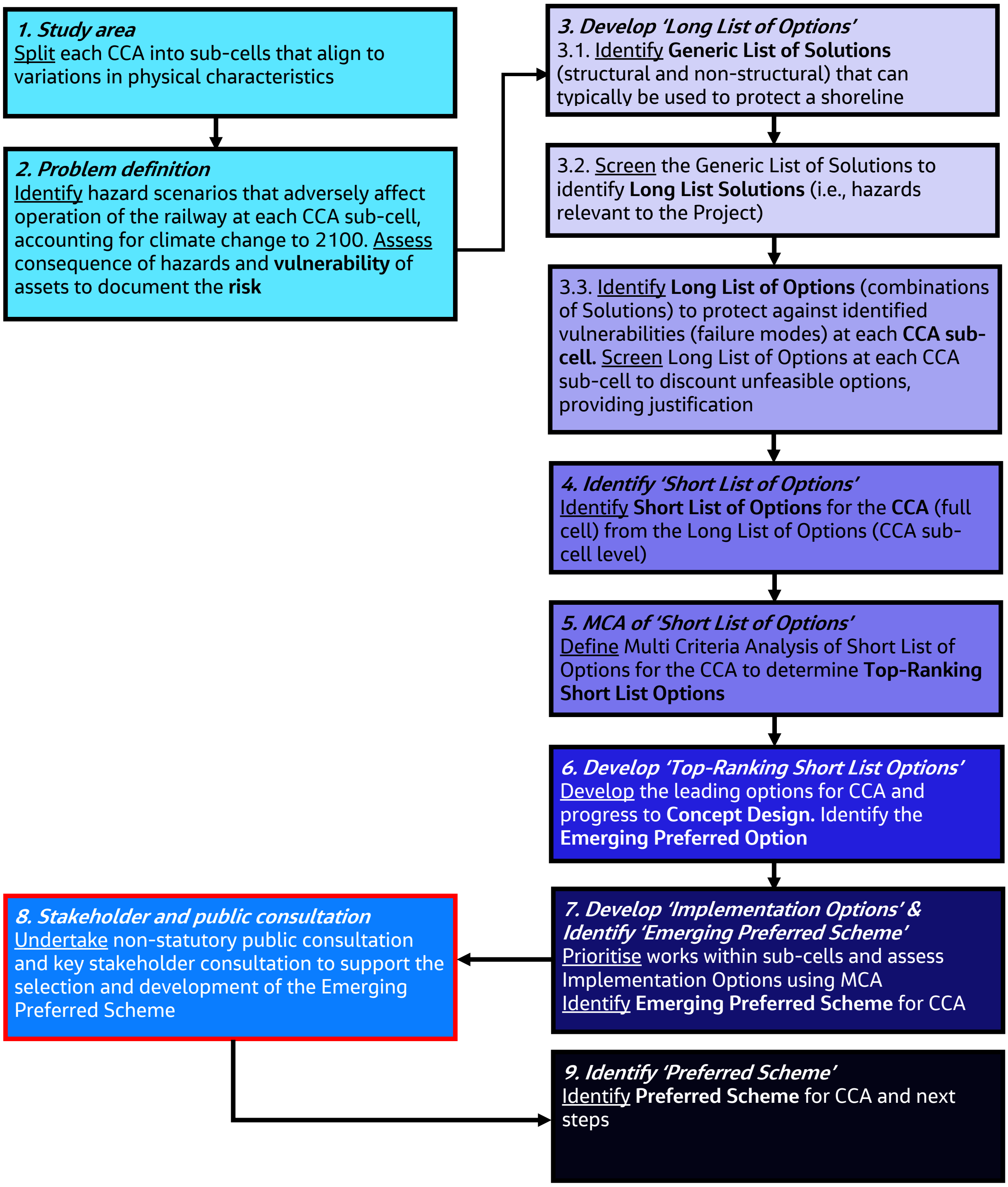

Figure 3-1 Flow Chart Summarising Optioneering Process

The flow chart in Figure 3-1 provides a summary of the overall options assessment methodology adopted for the Project.

3.2 Step 1: Study Area

The spatial model for this assessment uses sub-cells, also termed coastal/cliff behaviour units. These are a subdivision of the Coastal Cell Areas (CCAs), based on the variation in physical characteristics, including the geology, geomorphology, shoreline topography and orientation, and existing defence type.

The sub-cell delineation aligns with environmental constraints/characteristics where required, such as terrestrial/marine habitats and environmental designations. These sub-cells are then defined by a unique reference, description and associated shoreline chainage.

3.3 Step 2: Problem Definition

The hazard scenarios (failure modes) are identified and summarised for each CCA sub-cell based on the physical characteristics and existing defence forms of the sub-cell, accounting for climate change. These failure modes cover a range of scenarios including wave overtopping of structures, foreshore/beach lowering, beach/cliff erosion.

The potential consequences of these hazard scenarios to the railway with existing defences are identified for each sub-cell. In some cases, hazard scenarios may result in minor to moderate impact on the railway, interrupting services from less than a day to up to a month. Whilst other hazard scenarios may result in more significant impacts to operation of the railway whereby the line is severed and there is a risk of derailment. Different hazard scenarios and associated consequences give rise to relative differences in risk between the CCA sub-cells. The evaluation of risk for each sub-cell supports decision-making on locations where engineering will be required to mitigate risk to the railway, and locations where risk is negligible and does not need engineering intervention.

At this stage, a detailed description of the Do Nothing option for the CCA is provided as a baseline case against which all maintain or improve options are assessed against. The Do Nothing details how existing protection measures (natural systems and manmade coastal defences) would be expected to degrade and fail in the absence of any maintenance and how this will lead to increased disruption and eventual abandonment of the railway line. The Do Nothing option will be considered as a “walk away” solution, with only provision for making the area safe, for example through signage and fencing.

3.4 Step 3: Develop ‘Long List of Options’

The Long List of Options considers the range of interventions and measures that could be used to meet the Project objectives of protecting the railway line from coastal erosion and flooding.

The approach to identifying the Long List of Options is summarised as follows:

1. Generic List of Solutions: generic list of structural and non-structural coastal engineering solutions.
2. Long List of Solutions: screening of Generic List of Solutions for those that could be considered.
3. Suitability Matrix and Long List of Options: Identification of options (combinations of solutions) for each CCA sub-cell.

These tasks are described in detail below.

<u>Step 3.1 Generic List of Solutions</u>

The Generic List of Solutions lists the full range of possible engineering measures that can be used to protect a shoreline. This is not specific to the Project area or any specific location, but outlines the full range of structural, non-structural options and nature-based solutions, regardless of whether they could be viable for any of the Projects. This separates out the key elements of a coastal defence system.

The Generic List of Solutions includes options for materials and basic technical descriptions of how each solution works and key information such as high level benefits and negatives. The list summarises what failure mode each solution addresses and whether the solution addresses erosion and/or flooding hazards.

Step 3.2 Long List of Solutions

The Generic List of Solutions are screened to robustly discount solutions that are not considered to be feasible measures to meet the Project objectives at any location. Clear reasons for discounting are provided to serve as a baseline for the environmental assessment process. At this stage solutions are not discounted on environmental or economic grounds unless there is a clear reason for the option not to progress due to environmental and or economic reasons. Reasons for discounting solutions include:

- Solutions that do not address the hazards or failure modes;
- Solutions that will have significant and unacceptable negative impacts on the local and wider area;
- Solution does not have a proven track record or design standards in the proposed environment;
- Solution would pose significant and unacceptable constructability and HSE challenges;
- Solution has no benefit over an alternative but similar preferable solution;
- Solutions that will not meet the project requirements of providing long-term flood and coastal protection; and
- Solutions that will have an unacceptably high maintenance burden.

The requirement for a minimum 50-year Design Life (to 2075) and 25 years zero heavy maintenance is factored into the solutions taken forward:

- Each Solution is appraised against the requirement to achieve the design life for all new structures. The design life is the period of time after installation during which the structure meets or exceeds the performance requirements. Where this is not considered possible, the long list solution is screened out.
- Each Solution is assessed on the anticipated maintenance burden over its design life. High maintenance solutions are generally discounted. This is assessed as follows:
  - Low – only occasional monitoring and occasional repair is expected to be required to retain Standard of Protection of the defence
  - Medium – regular monitoring and regular light maintenance is expected to be required
  - High – regular monitoring and regular heavy maintenance and/or rebuilding of asset.

In some instances, it is necessary to retain a solution that independently is not considered technically feasible, but when combined with another solution to form a hybrid solution it would become technically feasible. These solutions are combined to form options at the CCA long list stage.

Do Nothing and Do Minimum Options are retained as baseline scenarios as described below.

- **Do Nothing –** this is the 'walk away' option. The current approach to managing the defences would stop; no repairs, maintenance or upgrades would be undertaken i.e., the solution represents a walk away from all maintenance and not just a walk away from the Project. Over time the structures will fail and closure of the railway line will be necessary as CCAs progressively become unsafe to operate. There will be costs involved with managing the Health, Safety and Environment (HSE) risks of the structures failing (e.g. signage or fencing to prevent access) but there will be no inspection, maintenance or repair costs involved.
- **Do Minimum –** this represents the current maintenance regime of ongoing monitoring and reactive repairs. Beyond inspections and ongoing maintenance on an as needed basis, there is little opportunity for a strategic, long-term planning of works under the Do Minimum option to proactively upgrade defences. Works are undertaken to repair the defences as required to protect the railway line. This will eventually lead to very high levels of disruption and the likely loss of the service in the longer term as the line becomes economically unviable due to disruptions and almost continual emergency works to maintain defences.
- **Do Something –** this term represents all intervention options considered under the Project to proactively maintain coastal defences to safeguard the continued operation of the railway. The remaining Solutions that are retained for more detailed screening at the CCA level will become the Long List Solutions.

Step 3.3 Suitability Matrix and Long List of Options

Requirements for each CCA sub-cell (hazard, failure modes) are cross-referenced in a suitability matrix against the Long List Solutions to identify the Long List of Options for each CCA sub-cell. The Options for each CCA sub-cell are comprised of combinations of Solutions.

Options are further screened at this stage to discount options that will not meet the objectives or technical requirements for the given CCA sub-cell accompanied by a clear reason for discounting to serve as a baseline for the environmental assessment process. Innovation and sustainability are critical factors that are considered at this stage.

3.5 Step 4: Identify 'Short List of Options'

A range of Short List Options for the CCA are identified by summarising combinations of sub-cell solutions (Long List Options on a sub-cell level) to form an overall CCA Short List of Options. The Short List of Options comprise those options which are likely to be technically feasible.

For many of the Short List Options, the same solution (Long List Option) is applied across all sub-cells. In some cases, a Short List Option can comprise different solutions across the sub-cells. Where combinations of solutions are grouped together, these have been combined based on engineering judgement to provide a coherent and complimentary approach for the overall CCA.

3.6 Step 5: MCA of 'Short List of Options'

The Short List of Options pass through to the Multi-Criteria Assessment (MCA) stage where the key risks, opportunities, advantages and disadvantages are identified. The leading options from the MCA (Top Ranking Short List Options) are then developed to concept level design sufficient to inform the preliminary options costing stage.

An MCA has been developed having regard to the Department of Transport Tourism and Sport (DTTAS), Common Appraisal Framework (CAF) for Transport Project and Programmes March 2016 (updated October 2020) for options assessment. A further sensitivity analysis was undertaken to address changes due to the Transport Appraisal Framework (TAF) Guidelines (Department of Transport, June 2023).

MCA can be used to describe any structured approach to determine overall preferences among alternative options, where the options should accomplish multiple objectives. The term covers a wide range of techniques that share the aim of combining a range of positive and negative effects in a single framework to allow for easier comparison of alternative options in decision-making (CAF, 2016).

The MCA was undertaken to consolidate the quantifiable and non-quantifiable impacts associated with the Short List of Options. MCA establishes preferences between options by reference to an explicit set of objectives that the decision-making body has identified, and for which it has established measurable criteria to assess the extent to which the objectives have been achieved.

3.6.1 Multi-Criteria Analysis Criteria

A modified, project-specific options assessment criteria was established in order to capture an appreciation of the constraints and opportunities within the study area as well as the defined technical aims and objectives of the Project. These were tailored to have commonality to the CAF guidelines where practical, and to include additional criteria where necessary.

The CAF Guidelines (DTTAS, 2016) require projects to undergo a multi-criteria analysis under a common set of CAF core criteria described in Table 3-1. Two additional core criteria have been included in this MCA:

- **Engineering/Technical** criteria were added to the assessment to capture the technical aims of the Project.
- **Planning Risk** in regard to the potential for non-compliance with applicable planning policy has been reviewed. By including this consideration within the assessment, it allows the MCA to identify options that are potentially more suitable from a consenting perspective at each location. Furthermore, consideration of planning risks highlights those options considered to have greater potential to be stalled and/or refused in the planning process. This is particularly important as each location has different requirements, sensitive receptors and ecological designations.

The CAF Guidelines are used as a basis to inform the development of the respective sub-criterion which are adapted based on project-specific aims and objectives, as shown in Table 3-1. The criteria and sub-criterion are the measures of performance by which the options are assessed.

Table 3-1 Modified MCA core criteria and objectives

Core Criteria	Objective	Description
Economy	Land Use & Third Party Assets	Impact on to third party land and property – cost.
	Capital expenditure	Total cost for implementation of option
	Maintenance expenditure	Costs associated with Operational & Maintenance
Safety	Health & Safety (Construction)	Health and safety risk and effect of options during construction.
	Health & Safety (Design Life)	Health and safety risk and effect of options during design life.
Accessibility & Social Inclusion	Community	Risk or opportunity for social/community infrastructure (e.g., schools and educational facilities, libraries, community centres, local and central government offices, emergency services facilities, health centres, religious centres, sports facilities, playgrounds, local cultural heritage sites, etc.) and Local Employment.
	Access	Maintenance of existing and where possible create new access to public and private property (e.g., access to properties, adjoining beaches, coves, headlands, maintenance of continuity of walking routes).
	Social & Recreation Facilities	Maintain existing and where possible create new social, recreational and community facilities (e.g., creation of new beach or extended beach area).
Integration	Compatibility with Development Plans	Compatibility to County Development Plans, Local Area Plans.
	Compatibility with Climate Adaptation Plans	Compatibility with relevant plans and strategies to climate adaptation.
	Compatibility with Transport Plans	Compatibility with relevant plans and strategies to transport.
Environment	Biodiversity	Significant negative impacts on sites of ecological importance and opportunities for significant positive impacts on sites of ecological importance i.e. "incorporation of Ecological engineering features (as required under National Biodiversity Plan)" .
	Landscape & visual & Seascape	Significant effects on protected views/ key views/landscape character (both positive & negative);
	Archaeology, Architectural & Cultural Heritage	Overall effect on cultural, archaeological and architecture heritage resource. Likely effects on RPS, National Monuments, SMRs, Conservation areas, etc. Number of designated sites/structures (by level of protection)
	Noise and Vibration	Estimated number of sensitive receptors likely to be affected by construction related noise with the scheme.
	Air Quality	Local air quality effects associated with construction phase of the project.
	Carbon Management	Relative assessment of embodied GHG emissions per option
	Water Resources	Overall potential significant effects on water resource attributes likely to be affected during construction and operation. WFD and status to be considered

Core Criteria	Objective	Description
	Geology and Soils	Likely impact on geological resources based on preliminary/likely construction details.
	Material & Circular Economy	Quantity of material required, type of material and opportunities for reuse. Material Balance.
	Waste	Waste generation, compliance with circular economy
	Traffic & Transport	Likely impacts on traffic & transport
Engineering / Technical	Constructability	Complexity of construction, translating into construction programme and cost risk. Requirement for specialist/marine plant
	Rail service impact	Impact on rail services during construction (severity/duration of impacts)
	Reliance on maintenance	Reliance on monitoring, maintenance and/or adaptation to provide consistent Standard of Protection.
	Adaptation	Options for future coastal defence adaptation in line with realised climate change impacts
	Residual risk	Susceptibility to Speed/criticality of defence failure should it become compromised (exceeding standard or due to poor maintenance).
Planning Risk	Consenting risk	Compliance with applicable planning policy, IROPI

3.6.2 MCA Scoring

The assessment undertaken is of a comparative nature (options compared against each other). This is based on the CAF criteria and based on professional judgement in respect of the items to be qualitatively evaluated, and comprehensively assessed against the key relevant criteria in accordance with good industry practice.

The assessment compared the relevant Short List of Options, identifying and summarising the comparative merits and disadvantages of each alternative under all the applicable criteria and sub-criteria leading to the Top-Ranking Short List Options. A comparative assessment was undertaken for each option developed, where in general, for each positively scored option there must be an opposing negatively scored option. Table 3-2 provides an overview of the comparative colour coded scale for assessing the criteria and sub-criterion. For illustrative purposes, this scale is colour coded with advantageous options graded to 'dark green' and disadvantaged options graded to 'red'.

Table 3-2 Comparative Colour Coded Scale for Assessing the Criteria and Sub-Criteria

Colour/Score	Description
Red	Significant disadvantages over other options
Orange	Some disadvantages over other options
Yellow	Similar to other options
Light Green	Some advantages over other options
Dark Green	Significant advantages over other options

For each individual assessment the parameter and associated criteria and sub criteria are considered, and options are compared against each other based on the comparative scale, ranging from having 'significant advantages over other options' to having 'significant comparative disadvantages over other options'. Options that are comparable were assigned 'comparable across all other options'. Options were compared under each criterion, before those criteria are aggregated to give a summary score for each parameter. The aggregated assessment considers the potential impacts and significance of those impacts when compared with the other options being assessed. The aggregated scores are compared to establish the options with more advantages over other options arriving at the Top-Ranking Short List Options. The MCAs are presented in the MCA matrices contained in the individual chapters in this report. The justification for the scoring for the options under each sub-criterion are detailed in the MCA matrices.

NOTE: A degree of professional judgement was used by the specialist undertaking the assessment. For example, environmental criterion assessments take into consideration the comparative likely potential impact and the degree of significance of the environmental factor to be impacted which is reflected in the aggregated summary ranking of that criterion.

3.7 Step 6: Develop 'Top-ranking Short List Options'& Identify ' Emerging Preferred Option'

The Top-Ranking Short List Options for the CCA are determined from the MCA analysis of Short List of Options, as described in Step 5. These options are progressed to Concept Design level, whereby the engineered solutions are described and presented, and the options are modelled and costed.

The Emerging Preferred Option (EPO) to be taken forward is identified from the Top-Ranking Short List Options. A summary of the metrics supporting the identification of the EPO are provided, describing the key outcomes of the MCA, including the advantages, disadvantages and risks.

3.8 Step 7: Develop 'Implementation Options' & Identify 'Emerging Preferred Scheme'

The works for the Emerging Preferred Option (EPO) within each sub-cell of the CCA were prioritised based on the current vulnerability of the railway to coastal hazards. This identifies when works would need to be undertaken to protect the railway line in the short-term (to 2050), medium-term (to 2075) and long-term (to 2100).

The priorities on a sub-cell basis were identified through consideration of the following aspects:

- Where coastal erosion and shoreline recession is active, what land buffer is there between the shoreline and the railway. Where this buffer is minimal, the works are assigned a higher priority. Conversely, if there is a large buffer of land it is preferable to allow the coastline to evolve naturally and assign a lower priority.
- Does longshore coastal modelling undertaken under ECRIPP indicate the future shoreline (considering climate change impacts) as being erosional or accretional into the future. This is assessed alongside the buffer to identify priorities.
- Where beaches are the primary defence of a shoreline, how susceptible are they to cross-shore erosion during a storm, resulting in a risk of erosion or wave overtopping at the back of the beach. This is assessed through coastal analysis and modelling. The larger the beach cross section, in combination with the stability of the beach (factors include beach material size and longshore sediment transport), the lower the priority for works.
- For cliffed sections of coastline, does wave overtopping of the shoreline realise a risk of toe erosion of the cliff and how does this risk increase in line with climate change impacts. Vertical cliffs recede in a more controlled and predictable manner but complex slumping cliffs require a larger buffer to the railway line to accommodate uncertainty and works would have a higher priority if this buffer is minimal.
- For low-lying sections of railway, does wave overtopping lead to a risk of damage to the railway infrastructure or failure of the back of the defence and how does this vary in line with climate change impacts. Where high overtopping rates risk service disruption or damage, a higher priority is assigned.
- Are existing structures vulnerable to undermining due to lowering of the foreshore. Structures that are at higher risk of undermining and could lead to a sudden collapse are given a higher priority.
- How vulnerable is the existing defence to catastrophic failure due to wave impact forces or wave overtopping which could lead to an immediate undermining risk to the railway. The higher the vulnerability, the higher the priority.
- Is a reactive and piecemeal approach to maintenance of the existing structures feasible to protect the railway. Where structures could fail quickly and maintenance access is difficult this would be classed as a higher priority.

Implementation Options were developed for the CCA, identifying options for prioritising works to align with increasing coastal hazard and risk to the railway, in line with realised climate change impacts and coastal change. These options were assessed using an MCA analysis undertaken having regard to the Transport

Appraisal Framework (TAF) Guidelines (Department of Transport, June 2023) to identify the Emerging Preferred Scheme (EPS) capital works to be delivered under the Project.

A summary of the metrics supporting the identification of the Emerging Preferred Scheme (EPS) are provided, describing the key outcomes of the MCA, including the advantages, disadvantages and risks.

3.9 Step 8: Non-Statutory Stakeholder and Public Consultation

Stakeholder engagement and consultation during the design process is a key element to the delivery of the Project. The purpose of these consultations is to engage the public in the scheme's delivery process, inform the public of the statutory process and likely timescales, seek the public's cooperation and understanding of the Project and to capture local knowledge to inform the design.

Public participation is welcomed and encouraged throughout the design development process. It is planned that there will be two non-statutory public consultation stages which provide the opportunity to learn about the design development and provide feedback which will inform the next stage as appropriate. Public Consultation 1 will be in Phase 2 on the Emerging Preferred Scheme. Feedback received during public consultation one will be used to inform subsequent designs before Public Consultation 2 in Phase 3 on the Preferred Scheme. Figure 3-2 provides a roadmap to the public consultation process.

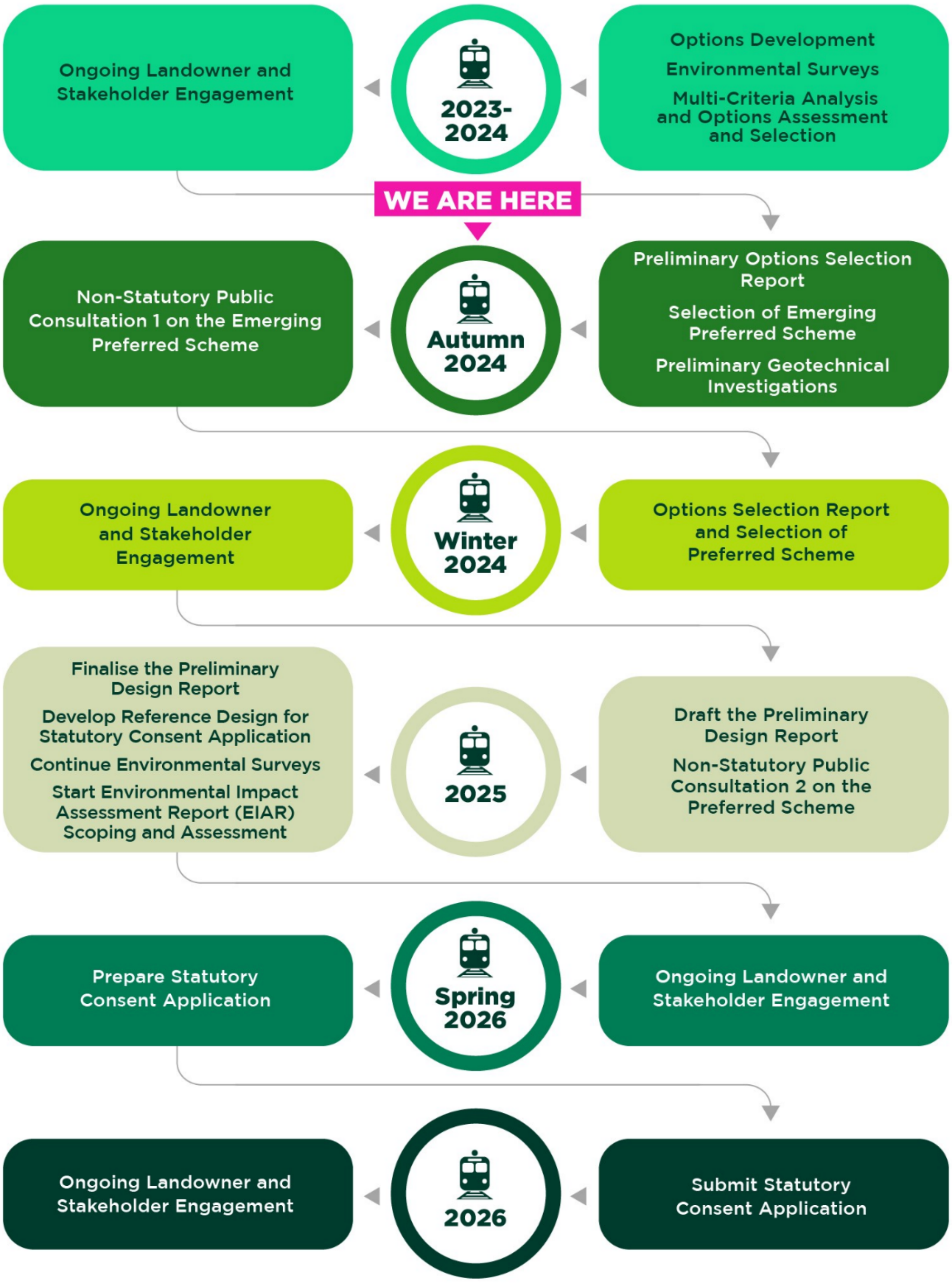

Figure 3-2 Public Consultation Roadmap

3.10 Step 9: Identify 'Preferred Scheme'

The Preferred Scheme is confirmed following consultation with the public and key stakeholders. Each engineered component of the Preferred Scheme is described, and a preliminary outline of the key delivery areas is provided.

The future Project phases to develop and deliver the Preferred Scheme are described in the concluding section of this report.

4. Study Area

4.1 Coastal cell area CCA6.1

The Project area is divided into Coastal Cell Areas (CCA). CCA 6.1 covers the frontage from south Greystones down to Newcastle.

CCA6.1 is approximately 8.5km long; the trainline runs along a natural embankment at the back of the beach. This is a barrier beach feature and is soft; underlain by hard geology. The railway is locally protected by long sections of rock revetment. CCA 6.1 also includes the Breaches, an area of land that is reclaimed intertidal land. CCA6.1 is located within a number of designated sites which are outlined in Section 4.3.

The main hazards are wave overtopping (the railway is very low-lying and the beach is generally narrow) and steepening and narrowing of the beach due to long-shore transport. The latter hazard may lead to undermining of the rock structures and the railway in the long-term.

4.2 Identification of Coastal Sub-Cells

CCA6.1 has been divided into five sub-cells based on the variation in physical characteristics, including the geomorphology, shoreline topography and orientation, environmental constraints, and existing defence type and the exposure due to different failure modes. The CCA sub-cells are shown and described in Figure 4-1 and Table 4-1. A photographic record showing the key defences and physical characteristics of each sub-cell are in Appendix B.

Further subdivision of the sub-cells for prioritisation of works is described in Section 5.6.

4.3 Environmental Constraints

In order to understand the baseline conditions of CCA6.1, a Planning and Environmental Constraints Report was produced. This report outlines constraints for a number of environmental topics which include:

- Biodiversity
- Soils & Geology
- Waste
- Hydrogeology
- Hydrology
- Landscape, Seascape & Visual
- Archaeology & Cultural heritage
- Air Quality & Climate
- Noise & Vibration
- Population & Human Health
- Traffic & Transport
- Material Assets

A summary of the constraints for CCA6.1 is included within this section. It should be noted this is a high level overview of some key constraints that were identified. The Planning and Environmental Constraints Report has been included as part of Appendix A.

4.3.1 Biodiversity

The main biodiversity constraints identified include:

- European Designated Site: The Murrough SPA (Code 004186) and the Murrough Wetland SAC (Code 002249);
- Nationally designated sites: Murrough pNHA (Code 000730);
- Presence of previously rare and legally protected Oysterplant (*Mertensia maritima*) (Flora (Protection) Order, 1999);
- One of the largest colonies of Little Tern at Kilcoole and the site now supports one of the largest colonies in the country. Birds nest along the entire stretch of the shoreline;

- Light-bellied Brent Goose occurs here in internationally important numbers; and
- There are priority habitats along the southern area of the CCA at Newcastle within the East Coast Nature Reserve.

4.3.2 Soils & Geology

The main constraints for soils and geology that were found are as follows:

- Steep topography is present within the vicinity of Wicklow and Rathnew towns;
- Moderately high landslide potential at Greystones;
- Several surface watercourses intersect the railway line through the cell;
- Fen peat has been identified in the cell and represents a natural form of carbon storage;
- Fen peat and alluvium deposits have been identified in the cell, which typically represent soft or loose soils that are compressible or poorly consolidated;
- Potential sources of contamination:
  - Urban made ground
  - Former pits are present in the vicinity of the railway line
  - Clusters of historic and current industrial land uses are present in the developed areas of Newcastle, Greystones and Kilcoole
- A number of geological faults intersect the railway line within the cell;
- Gravels beneath Kilpedder identified as a locally important aquifer;
- A number of domestic abstraction wells are present through the cell;
- Moderate to extreme areas of groundwater vulnerability are present;
- Moderate to very high granular aggregate potential;
- Moderate to very high crushed rock aggregate potential; and
- The Marine Beach Sands along the coastline are identified as a Geological Heritage Audited Site.

4.3.3 Hydrology

The main constraints for hydrology that were found are as follows:

- Waterbodies:
  - Seven river sub-basins: Kilruddery_Deerpark_010 , Three Trouts Stream_010, Kilcoole Stream_010, Ballyronan Stream_010, Newtownmountkennedy_020, Newcastle (Wicklow)_010
  - One transitional waterbody: Kilcoole Marsh
  - One coastal waterbody: Southwestern Irish Sea – Killiney Bay (HA10)

Areas subject to flood risk includes:

- Coastal area from Greystones as far south as Cobblers Bulk, just east of Ballynerrin; and
- Flooding along the Kilcoole Stream, Ballyronan Stream, Newtownmountkennedy Stream and Newcastle stream flowing into the Murroughs.

4.3.4 Landscape, Seascape & Visual

The main constraints for Landscape, Seascape & Visual that were found are as follows:

- Area of trees under Tree Protection Order at Kilcoole;
- Two prospects;
- Two landscape areas – Bray Mountains Group and Northern Coastline;
- Seascape Character Area (SCA) – SCA 14 Irish Sea, Sandbanks and Broad Bays; and
- Seascape Coastal Type - SCT7- Broad Estuarine Bays and Complex Low Plateau and Cliff Coastline.

4.3.5 Archaeology & Cultural heritage

The main constraints for Archaeology & Cultural Heritage that were found are as follows:

- 101. No. SMR Sites; and
- Two Undesignated Key Constraints:

- One historic railway line within CCA6.1: Bray to Wicklow
- Three historic railway stations within CCA6.1: Greystones, Kilcoole and Newcastle

4.3.6 Air Quality & Climate

No significant constraints have been identified in relation to air quality and climate. However, there are air quality sensitive receptors that were identified within the study area. These include but are not limited to:

- Residential properties;
- Designated habitats (e.g., SAC or SPA) and ecologically sensitive areas;
- Amenity/recreational areas;
- Educational facilities; and
- Healthcare facilities.

4.3.7 Noise & Vibration

No significant constraints have been identified in relation to noise and vibration. However, there are a range of noise sensitive receptors that have been identified within the study area. These include but are not limited to:

- Residential properties;
- Schools;
- Medical facilities;
- Heritage buildings;
- Designated habitats (e.g., SAC or SPA) and ecologically sensitive areas;
- Place of worship or entertainment; and
- Commercial buildings with noise/vibration sensitive equipment i.e., recording studios or research and manufacturing facilities.

4.3.8 Population & Human Health

No significant constraints have been identified in relation to population & human health. A baseline review was undertaken to identify local receptors which include but are not limited to:

- Residential properties;
- Schools;
- Medical facilities;
- Commercial buildings; and
- Recreational facilities.

Figure 4-1 CCA6.1 sub-cells

4.4 Hazard Identification and Failure Modes

The existing defence forms and their exposure to different hazards (failure modes) have been identified for the CCA sub-cells. The Long List of Solutions (Section 5.1.2) are considered against the same list of hazards for each sub-cell.

The failures modes identified for the Project encompass the following:

- **OT**: Wave overtopping leading to structural damage behind the defence and/or erosion of rear embankment slope (and disruption to services)
- **ST**: Structural failure of existing hard defences from wave impact (covers blocks/rocks displacement, concrete loosing strength/cover, mortar loss leading to voids, overloading retaining walls etc)
- **TS**: Toe scour at structures in response to storm conditions leading to undermining of structures (episodic and relatively localised)
- **BE**: Beach erosion and retreat of the shoreline in the longer term in line with sea level rise (long-term trend caused by lack of sediment supply affecting larger areas)
- **TE**: Toe erosion of cliffs leading to undercutting, oversteepening and cliff recession, predominantly through mudslides. Erosion will be greater in times of low beach levels coincident with storms
- **GW**: Cliff failure through elevated groundwater levels that raise pore water pressures, weaken 'soft cliff' materials and promote failure. Failures triggered by persistent wet weather (high antecedent rainfall).
- **RF**: Rock falls and other bedrock failures associated with weathered and weakened rock slopes in cuttings, natural sea cliffs and crags above the railway. Includes mobilisation of existing screes. Weathering driven by seasonal freeze-thaw. Failure may be triggered by exceptional rainfall, seasonal thaw or extreme dry conditions.

A summary of the existing defence forms and their hazard exposure is provided below in Table 4-1.

4.5 The Do Nothing Scenario

The coastal hazards could present a range of risks to the railway operations if there are no intervention measures to manage coastal erosion and flooding hazards.

Table 4-2 describes the potential failure modes associated with the various coastal hazards (identified in Section 4.4) and provides a commentary on how risks to the railway could manifest in the absence of intervention measures. This represents the Do Nothing scenario. The table also identifies the most vulnerable sections of the frontage under each failure mode.

Intervention measures range from current maintenance and reactive repairs through to strategic and holistic improvement of the defences under the Project.

Table 4-1 Defence forms and failure modes at each CCA sub-cell

Sub-cell	Name	Defence form and hazard exposure	Failure modes						
			Wave overtopping	Structural failure	Toe scour	Beach erosion	Toe erosion	Ground water	Rockfall
CCA6.1 - General	Greystones South to Newcastle	Variation of revetments and seawalls and unprotected vegetated dunes. Rail line setback from coast varies. Coastline generally low lying with no cliffs of note	ü	ü	ü	ü			
CCA6.1-A	Greystones	Shoreline has relatively wide beach. Beach levels are volatile but generally recover after periods of erosion. High seawall at north of section by the station. Seawall lowers and then stops. Rear of beach is vegetated with underlying gabions/rock armour. Erosion of beach in southern section of cell likely to occur and result in OT issues by 2100 as no seawall in this area. Approx 1.0km long	ü			ü	ü		
CCA6.1-B	Cobblers Bulk	Rock revetment along full length of sub-cell. Rock armour appears to be a suitable grading but has been poorly constructed. Very steep with poor interlock. Approx 2.0km long	ü	ü	ü	ü	ü		
CCA6.1-C	Kilcoole	Rock revetment/dune toe protection along majority of sub-cell. Central section of sub-cell has a wider healthier beach than the northern and southern parts. Approx 1.7km long	ü	ü	ü	ü			
CCA6.1-D	Cooldross	Mostly unprotected beach with vegetation at crest of beach. Shingle on crest suggests wave action does reach the crest. No wave wall at rail line. Approx 1.6km long This section includes the Breaches.	ü			ü			
CCA6.1-E	Newcastle North	Unprotected frontage. Vegetation at crest of beach. There may be some underlying concrete defences. Approx 0.5m concrete blocks with fence on top along rear of beach in some sections. Small rock revetment at south of section, around Newcastle station. Approx 2.2km long	ü			ü			

Table 4-2 Risk to the railway due to various failure modes in Do Nothing scenario

Hazard/ Failure Mode	Risk to the railway (vulnerability) in the Do Nothing scenario	Most vulnerable areas
Wave Overtopping	• Wave overtopping is currently a medium risk to the railway line through CCA6.1. This risk will increase significantly with sea level rise projections. • During high tide in storm events, wave overtopping over the rock revetments and natural shoreline onto the line has historically led to localised dislodgement of track ballast and localised scour behind the defence (in the more exposed locations). • The most likely impact is the loss of material behind the rock revetments/shoreline and washout of ballast, which could force temporary closure of the line during and after a significant storm. There is a risk of wave overtopping causing flooding on the line, but given the ground is relatively permeable, this is likely to be a short-lived problem during a storm and immediately following a storm. • As sea levels rise, the volumes of wave overtopping will increase significantly and this overtopping will become a more regular event. The likelihood of enough ballast being dislodged to destabilise the track will increase with time. This will lead to speed restrictions and increased frequency of short periods of line closure. • In the Do Nothing scenario repairs would not be undertaken to the railway infrastructure or the rock revetments, and the line would ultimately have to be closed following a storm of sufficient magnitude for wave overtopping to cause erosion of the ballast and undermining of the track. There is a very high probability this would occur in the longer term in the Do Nothing scenario based on this failure mode. • In addition to the risk to the railway operation and assets covered by the Project scope of work, wave overtopping presents a significant risk to pedestrians using the informal footpaths behind the beach/defences.	• The vulnerability at a location is directly linked to the storm wave height /direction /period, water level (all of which vary for a given storm), the defence form/height and the beach levels. • Vulnerability varies, but in general the risk of overtopping is higher where the beach is narrower and the railway is closer to the shore e.g. Cobblers Bulk and Kilcoole. Where the beaches are fuller and the modelling is showing an accretional trend, the risks are lower e.g. Greystones, Cooldross and North Newcastle
Structural Failure	• Structural failure of the current defences (where present) is currently a medium to high risk to railway operations in CCA6.1. This risk will increase appreciably with sea level risk projections as larger waves would reach the defences on a more regular basis. There will also be a loss in protective beach material on the frontage. • Irish Rail has historically maintained the defence to repair sections where the existing rock revetments have failed. These failures are typically due to of a combination of undersized, or poor quality, rock; and a structure geometry that is too steep or has insufficient toe depth to prevent undermining. • In the Do Nothing scenario, localised failures in the rock revetments would propagate and the overall structural integrity of the defence would be compromised as rocks displace (typically seaward). This would eventually lead to the failure and lowering of the upper parts of the	• The vulnerability at a location is directly linked to the storm wave height /direction /period, water level (all of which vary for a given storm), the defence form/height and the beach levels. • Vulnerability varies, but in general the risk of overtopping is higher where the beach fronting the defence is narrower and the railway is closer to the shore e.g. Cobblers Bulk and Kilcoole. Where the beaches are fuller and the modelling is showing an accretional trend, the risks are lower e.g. at Newcastle

	revetment. The closure of the line would then typically occur due to the resultant increase in wave overtopping, direct flows of waves over the railway or a recommencement of erosion of the hinterland. Given the poor condition of some of the existing revetments, there is a very high probability this would occur in the longer term in the Do Nothing scenario based on this failure mode. • As sea levels rise, larger waves will reach the defence line, and this increases the risk that more significant failures could propagate quickly during a storm event. This could potentially cause a sudden and catastrophic collapse of the upper parts of the revetment. However, it is unlikely that this would result in such a sudden and dramatic way that would lead to a derailment, but this could be possible. • There would also be an increasing risk of a sudden collapse of the hinterland/footpaths leading to an increased public health and safety risk. This would likely lead the council eventually having to close these footpaths to manage this risk.	
Toe Scour	• At CCA6.1, the risk of scour undermining the defence is linked directly to the general foreshore/beach levels ahead of a storm (refer to the beach erosion failure mode below). • Toe scour is currently assessed a medium to high risk to railway operations in CCA6.1, but it is localised. This risk will increase significantly with sea level rise projections allowing larger waves to reach the defence line and cause more significant scour in-front of the revetments. • Historically there is evidence of scour of the beach/foreshore leading to an undermining of defences and failure/damage to the defences. Sometimes the full depth of scour during the peak of a storm event is not known as the scour hole can fill back up with foreshore material as the tide level/storm reduces. • Should the defence toe become undermined and exposed in a storm event, the risk to the railway is similar to the structural failure mode. This could result in a relatively quick failure but the risk of derailment remains low. • In the Do Nothing scenario the undermined defence would not be repaired and the failure would eventually undermine the upper sections of the rock revetment leading to a compromise in the overall structural integrity of the defence that would force the closure of the line on safety grounds. There is a high probability this would occur in the longer term in the Do Nothing scenario based on this failure mode.	• The vulnerability at a location is directly linked to the storm wave height/ direction/ period, water level (all of which vary for a given storm) and the defence condition/ form /toe depth. • Hence, vulnerability varies, but in general the risk of toe scour is higher where the beach fronting the defence is narrower and the railway is closer to the shore e.g. Cobblers Bulk and Kilcoole. Where the beaches are fuller and the modelling is showing an accretional trend, the risks are lower e.g. at Newcastle
Beach Erosion	• There are continual beaches throughout CCA6.1 and all other hazards are directly linked to the beach/foreshore levels. • Beach erosion is currently assessed a medium risk to railway operations in CCA6.1, but this is an undirect risk given beach erosion will lead to one of the other failure modes. This risk will increase with sea level rise due to the relative reduction in beach volume above the high tide level (the beach is the main coastal defence through this cell and there is no new source of beach material feeding into the cell to increase beach levels in line with sea level rise). Climate change will also	• Coastal modelling has shown the tendency for long term accretion at Greystones where the beaches are more stable and wider. There are other smaller areas showing accretional trends e.g. Cooldross. The risk of beach loss here is lower (inclusive of climate change impacts). • Long term erosional trends are more pronounced around Cobblers Bulk and Kilcoole where the beaches are currently narrower and suffer from more seasonal and storm variation.

	lead to a change in the coastal processes along the frontage resulting in increased erosion rates (where material will be pulled offshore and lost). • In the Do Nothing scenario, the beach volume relative to mean sea level will reduce and accelerated losses of material offshore would be expected. This will not directly put the railway at risk, but it will increase the likelihood of the other failure modes impacting the railway.	These are the locations where losses of beach material will expose the defences, slopes and cliffs to the other failure modes.
Toe Erosion	• Toe erosion during storms and/or in times of low beach levels has caused localised retreat of soft cliffs formed in weak glacial sediments that is measurable in historical maps and aerial photos covering the last c. 150 years. Most of this frontage is a gravel barrier that fluctuates in position in response to storms. Defences have been constructed to manage erosion at specific locations where the railway is close to the shoreline and threatened with erosion. • Under a Do Nothing scenario toe erosion is expected to increase if sea-levels rise or beaches diminish in size. Existing defences will be undercut and/or outflanked. • Projected erosion under projected sea-level rise suggests that the railway is at moderate to high risk of erosion over the long-term.	• Low-lying soft cliffs are located across most of CCA6.1. Risk varies according to beach size and distance of the railway from the shoreline but beyond the end of the defences north of Newcastle is particularly vulnerable.

5. Options Assessment

This section provides the results of the Options Assessment, from identifying the Long List of Options (Section 5.1) and the Short List of Options (Section 5.2), through to the Multi Criteria Analysis (Section 5.3), identifying the Top-ranking Short List Options for Concept Design (Section 5.4) and determining the Emerging Preferred Option (Section 5.5).

5.1 Long List of Options

The Long List of Options considers the range of interventions measures that could be used to meet the Project objectives of protecting the railway line from coastal erosion and flooding. Through a process of screening, this is reduced to a Short List of Options.

The approach to identifying the Long List of Options is summarised as follows:

1. Generic List of Solutions: generic list of structural and non-structural coastal engineering solutions.
2. Long List of Solutions: screening of Generic List of Solutions for those that could be considered.
3. Suitability Matrix and Long List of Options: Identification of options (combinations of solutions) for each CCA sub-cell.

The results of the Long List Options process are presented in Section 5.1.3 in Table 5-6 to Table 5-11.

5.1.1 Generic List of Solutions

The Generic List of Solutions lists the full range of possible engineering measures that can be used to protect a shoreline. This is not specific to the Project or a specific location but outlines the full range of structural, non-structural options and nature-based solutions, regardless of whether they could be viable. Hybrid solutions combine elements of structural and nature-based and are considered as combined solutions at a CCA-level. An overview of these solutions is provided in Table 5-1.

Table 5-1 Overview of generic list of solutions to protect a shoreline.

Structural	Nature-based	Non-structural	Hybrid
Seawalls	Beach nourishment	Floodplain policy and management	Managed realignment
Revetments	Dune restoration	Flood proofing and impact reduction	Ecologically enhanced vertical walls
Breakwaters	Shellfish reefs	Flood warning and preparedness	Breakwaters with beach nourishment
Groynes	Saltmarsh	Relocation	
Sills	Seagrass beds		
Embankments			
Rock netting			

5.1.2 Long List of Solutions

The Generic List of Solutions have been screened to identify options that can be discounted at this stage as not applicable to the Project or any sub-cell. The screening of the Generic List of Solutions is provided in Table 5-2, Table 5-3 and Table 5-4, for the structural, nature-based and non-structural solutions, respectively. The tables provide:

- Long List (LL) ID, name and description of the Solution,
- Design life and maintenance burden information,
- Whether the Solution is retained or discounted, coloured green and red in the table,
- Reasoning for discounting the Solution, based on whether or not the solution meets the Project objectives as outlined in Section 3.4.

The remaining Solutions that are retained for more detailed screening at the CCA sub-cell level are the Long List of Solutions.

Table 5-2 Long list of structural solutions.

ID	Solution	Description	Meets minimum design life?	Maintenance burden	Retained or discounted	Reason for discounting	Failure mode addressed						
							OT	ST	TS	BE	TE	GW	RF
LL04	Detached Breakwaters - emergent rock or concrete armour units	Large offshore structures which dissipate wave energy due to their size, roughness and presence of voids. This reduces the wave heights at the shoreline defences	Yes	Low	Retained					✓			
LL05	Detached Breakwaters - caissons	Large monolithic offshore structures which block waves due to their size. This reduces the wave heights at the shoreline defences	Yes	Low	Discounted	Technically feasible but discounted because: No distinct advantages over rock or concrete armour units; higher uncertainty in design, cost etc.				✓			
LL06	Detached Breakwaters - submerged reefs	Offshore structures which are fully below the normal tidal water level, reducing some of the wave transmission to the shoreline	Yes	Low	Discounted	Does not promote salient growth and will have limited impact on shorter period waves such as those seen in the study area				✓			
LL07	Attached Breakwaters - rock	Rock structures which extend from the shoreline into the nearshore and are large enough to dissipate wave energy under storm conditions	Yes	Low	Retained				✓	✓	✓		
LL08	Revetment - rock	Sloping rock structure along the shoreline which has a rough surface to dissipate wave energy and reduce wave overtopping	Yes	Low	Retained		✓	✓	✓		✓		
LL09	Revetment - concrete armour units	Sloping structure formed of precast concrete armour units along the shoreline which has a rough surface to dissipate wave energy and reduce wave overtopping	Yes	Low	Retained		✓	✓	✓		✓		
LL10	Revetment - smooth concrete	Sloping structure formed of precast or in-situ smooth concrete slabs.	Yes	Medium	Discounted	Requires more frequent maintenance and performs less well than other revetment solutions		✓	✓				
LL11	Revetment - stepped concrete	Stepped structure formed of precast or in-situ smooth concrete slabs. Steps dissipate some wave energy and allow some reduction in wave overtopping	Yes	Medium	Retained		✓	✓	✓				
LL12	Revetment - masonry	Sloping masonry structure similar to the existing defences in CCA1	Yes	High	Discounted	Requires more frequent maintenance and performs less well than other revetment solutions		✓	✓				
LL13	Revetment - open stone asphalt	Sloping structure formed of a bitumen-bound aggregate. Provides limited dissipation of wave energy due to the open layer structure	No	Medium	Discounted	Uncertainty in design life in more exposed locations (such as this). Could be viable as more of a maintenance measure.		✓	✓		✓		
LL14	Revetment - gabions	Sloping or stepped structure formed of wire cages filled with small stone. Provides some dissipation of wave energy and some reduction in wave overtopping	No	High	Discounted	Design life in the marine environment is limited to approximately 10 years and does not meet project requirements		✓	✓		✓		
LL15	Revetment - geo containers	Containers formed with UV-stabilised geotextile fabric and filled with sand	No	High	Discounted	Design life is unproven and is not expected to meet project requirements		✓	✓		✓		
LL16	Toe Protection - rock	Low-profile rock structure which provides added stability and erosion protection to existing structures and/or soft cliffs	Yes	Low	Retained				✓		✓		

LL17	Toe Protection - geotubes	Containers formed with UV-stabilised geotextile fabric and filled with sand	No	High	Discounted	Design life is unproven and is not expected to meet project requirements			✓		✓		
LL18	Toe Protection - gabions	Low-profile gabion structure formed of wire cages filled with small stone. Provides added stability and erosion protection to existing structures and/or soft cliffs	No	High	Retained	Although design life and maintenance burden do not meet the project requirements, these may be appropriate in areas of lower exposure and as part of cliff toe protection. This option is retained as a measure that can be replaced in the future and/or used alongside other measures to provide long term protection.			✓		✓		
LL19	Toe Protection - steel sheet piles	Steel sheet piles installed at the toe of existing structures and/or soft cliffs to provide added stability and erosion protection. Structure may exacerbate beach loss as vertical structures reflect more wave energy	Yes	Medium	Retained	Needs to be used as part of a combined solution, either to provide toe support as part of a revetment solution or with other scour protection in front of cliffs. Fully discounted as a stand-alone solution in the active zone			✓		✓		
LL20	Toe Protection - rubber tyres	Used rubber tyres are lashed together (for example in a honeycomb pattern) to protect existing structures and/or soft cliffs. Tyres can also be filled with stone, sand or concrete to increase their weight.	No	High	Discounted	Not suitable for high wave energy environments; does not have the robustness required for these locations. There are also concerns that material would degrade contaminating the sea/adjacent habitats			✓		✓		
LL21	Groynes - rock	Linear rock structure constructed perpendicular to the shoreline which helps retain beach material in place. Different plan configurations are possible, such as fish-tail and y-shaped groynes	Yes	Low	Retained	Note that groynes as a standalone measure will only be appropriate where there existing beach material is abundant. Elsewhere, beach nourishment would be likely to create a long-term solution			✓	✓	✓		
LL22	Groynes - timber	Linear timber pile and planking structure constructed perpendicular to the shoreline which helps retain beach materials in place.	No	High	Discounted	Timber groynes typically have a design life of less than 50 years in the marine environment and therefore do not have the required design life. They also require more maintenance than rock groynes			✓	✓	✓		
LL23	Vertical Seawall - concrete wall	Large vertical or near-vertical impermeable concrete structure designed to withstand high wave forces; may include a bullnose or recurve element to help reduce wave overtopping. A seawall can accommodate a promenade or other amenity feature	Yes	Low	Retained		✓	✓			✓		
LL24	Vertical Seawall - sheet piles	Steel sheet piles installed as prevention from wave overtopping; may include a concrete capping beam. Likely to require toe protection	Yes	Medium	Retained	As a combined solution with rock toe protection or as a set-back wall to reduce maintenance burden	✓	✓			✓		
LL25	Vertical Seawall - masonry	Large vertical or near-vertical impermeable masonry structure designed to withstand high wave forces. A seawall can accommodate a promenade or other amenity feature.	Yes	Medium	Discounted	Would require large volumes of rock, quarried and shaped into blocks; very labour-intensive and does not have any additional technical advantages when compared to a concrete seawall	✓	✓			✓		
LL26	Embankments / Levees	Linear grassed earth structure providing flood protection; typically used along riverbanks	Yes	Medium	Discounted	Not suitable for a coastal setting without a revetment or other protection							
LL27	Sills	Installation of a low rock structure in front of existing eroding banks to retain sediment behind. Depending on availability of suitable material, accretion may occur naturally, or recharge may be needed. Can also be used to form a perched beach reducing the footprint and volume of material import to create a beach.	No	Medium	Discounted	Best suited to low energy environments where there is a wide intertidal area; not technically feasible for an open coast frontage			✓	✓	✓		
LL28	Set back flood wall	Low vertical wall, typically made of concrete, masonry or steel sheet piles which is located behind the primary defence where it does not need to withstand direct wave impact; may be installed behind a promenade or beach nourishment	Yes	Low	Retained		✓						

LL29	Rebuild existing structures to required height	Dismantle and re-build the existing defences to meet current design standards and the required level to reduce wave overtopping. This may have a lower overall carbon footprint.	Yes	Medium	Discounted	The integrity of the existing materials is uncertain; this would also increase the vulnerability of the railway during the construction period and substantial temporary works would be needed to allow the railway to remain operational.	✓	✓					
LL30	Temporary flood defences (demountable?)	Includes flood gates and inflatable defences which can be deployed when needed.	No	High	Discounted	Need regular inspections and maintenance to know they can be deployed as needed. Not suitable for the scale of interventions needed to deliver resilience. May be suitable at very discrete locations where existing access to the beach needs to be maintained (e.g., at level crossings)	✓						
LL43	Soft cliff stabilisation - deep drainage systems	Deep drainage for landslide stabilisation employing 'passive' gravity drains, or 'active' pumped/syphon systems.	Yes	High	Discounted	Cliff instability is not driven by movement on deep shear surfaces.						✓	
LL44	Soft cliff stabilisation - shallow drainage systems	Surface water management to prevent and redirect flows discharging over the cliff	No	Medium	Retained	Will require periodic maintenance to ensure drains are cleared. Although the option is not able to provide protection on its own, this option is retained as a measure that can be replaced in the future and/or used alongside other measures to provide long term protection.						✓	
LL45	Hard cliff stabilisation - rock netting	Technically feasible and appropriate but 100 year design life for netting/bolting materials is not currently possible in the industry.	No	Medium	Retained	Currently available manufacturers' equipment has a limited design life and will require periodic maintenance. Although the option is not able to provide the required design life, this option is retained as a measure that can be replaced in the future and/or used alongside other measures to provide long term protection. New products may become available in the future.							✓
LL46	Hard cliff stabilisation - rock bolting	Technically feasible and appropriate but 100 year design life for netting/bolting materials is not currently possible.	No	Medium	Retained	Currently available manufacturers' equipment has a limited design life and will require periodic maintenance. Although the option is not able to provide the required design life, this option is retained as a measure that can be replaced in the future and/or used alongside other measures to provide long term protection. New products may become available in the future.							✓
LL47	Hard cliff stabilisation - large scale reprofiling	Reprofiling of Bray Head is not feasible given the volumes of rock needing removal. It may be feasible to undertake very localised reprofiling and/or removal of loose blocks.	Yes	Low	Discounted	Large-scale reprofiling of Bray Head is not feasible, but localised removal of loose blocks may be undertaken in tandem with other rock slope stabilisation measures.							✓
LL48	Hard cliff stabilisation - catch fences	Suitable for certain locations, but fences need maintenance after each rock-fall event.	No	High	Retained	Catch fences have a limited design life and will require periodic maintenance, particularly after a rock fall event. Although the option is not able to provide the required design life, this option is retained as a measure that can be replaced in the future and/or used alongside other measures to provide long term protection.							✓
LL49	Rock fall protection - rock fall shelter	Engineered structures with open sides that that extend from existing tunnels and protect the railway from falling debris.	Yes	Medium	Retained								✓
LL50	Rock fall protection - new/extended tunnels	Engineered structures with closed sides that protects the railway from falling debris and/or new tunnelled sections	Yes	Medium	Discounted	Localised new tunnels will be prohibitively expensive and are unlikely to be feasible given restrictions of railway alignment							✓

Table 5-3 Long list of nature-based solutions.

ID	Solution	Description	Meets minimum design life?	Maintenance burden	Retained or discounted	Reason for discounting	Failure mode addressed						
							OT	ST	TS	BE	TE	GW	RF
LL32	Beach Nourishment - beach recharge	Supplementing the existing beach periodically with suitable material (shingle, sand or a mixture to match the existing beach) to increase beach volumes, reduce erosion and toe scour at flood defences and/or soft cliffs. Usually requires control structures (groynes or breakwaters) to retain the material.	No	Medium	Retained	Although the option is not able to provide the required design life, this option is retained as a measure that can be replaced in the future and/or used alongside other measures to provide long term protection.			✓	✓	✓		
LL33	Beach Nourishment - beach recycling	Moving existing beach material from areas of accretion downdrift to areas of erosion updrift. This is best suited to areas where there is a well-defined longshore movement of beach material which accumulates at the downdrift end of a beach. Recycling activities would typically be undertaken annually.	No	High	Discounted	Will not achieve the required design life and needs significant and frequent maintenance. Therefore, does not meet needs of the project			✓	✓	✓		
LL34	Sand engine	Supplementing the existing beach with a very large recharge of suitable material (shingle, sand or a mixture to match the existing beach) to increase beach volumes, reduce erosion and toe scour at flood defences. Material is placed in the nearshore and waves/currents allowed to distribute naturally.	No	Medium	Discounted	Will not achieve the required design life. None of the beaches are sand beaches; the beaches are generally a sand-shingle mix. From a technical perspective, shingle would be preferred but this is un-proven.			✓	✓	✓		
LL35	Dune regeneration	Stabilisation and enhancement of existing dune systems to deliver additional resilience. Stabilisation could involve planting, thatching and fencing to trap windblown sand	No	Medium	Retained	Note: only relevant where dunes already exist at very specific locations along the study area. Although the option is not able to provide a long year design life, this option is retained as a measure that can be replaced in the future and/or used alongside other measures to provide long term protection.			✓	✓			
LL36	Vegetated features (e.g. saltmarsh)	Restoration or planting of saltmarsh or other vegetated features.	No	N/A	Discounted	Does not address any of the failure modes; there is no saltmarsh present in the study area and wave exposure is too great							
LL37	Maritime forests	Restoration or planting of kelp	No	N/A	Discounted	Does not address any of the failure modes; there is no kelp present and needs to be subtidal							
LL38	Oyster, mussel and coral reefs	Construction of sub-tidal or intertidal reefs using a suitable material for settlement by oysters or mussels.	No	N/A	Discounted	Structures are likely to be small in scale and therefore have limited influence on failure modes.							
LL39	Sea grass beds	Installation of intertidal or sub-tidal beds of sea grass. Provides ecosystem benefits including carbon sequestration. Seagrass is present in CCA1	No	N/A	Discounted	Needs sheltered waters; does not address any of the failure modes							

Table 5-4 Long list of non-structural solutions.

ID	Solution	Description	Meets minimum design life?	Maintenance burden	Retained or discounted	Reason for discounting	Failure mode addressed						
							OT	ST	TS	BE	TE	GW	RF
LL01	Do nothing	No further maintenance and intervention/repair only where required for public safety	No	Medium	Retained	Retained as a baseline option for the MCA							
LL02	Do minimum	Continue patch repairs/upgrades and reactive maintenance	No	High	Retained	Retained as a baseline option for the MCA							
LL03	Relocation of the railway	Construction of a new railway line with an inland or lower hazard route	Yes	Low	Retained	Low maintenance for defences; railway assets would be comparable to existing	✓	✓	✓	✓	✓	✓	✓
LL40	Floodplain policy and management measures	Managing flood and erosion risk by not allowing vulnerable infrastructure within zone of significant risk; typically, a government-led planning policy limiting future development rather than retrospectively to existing development	Yes	N/A	Discounted	Policy and management measures would not address any of the failure modes							
LL41	Flood proofing and impact reduction measures	Localised protection to individual assets/buildings to improve resilience to flooding. This might include demountable gates protecting doors and windows preventing flow into the assets/buildings. Would often be combined with a flood warning system to allow deployment in time.	Yes	N/A	Discounted	Flood proofing and impact reduction measures are best suited to critical assets in discrete locations; this may be appropriate for isolated structures along the railway (e.g., critical signalling infrastructure) but cannot be practically achieved along the whole study area	✓						
LL42	Flood warning and preparedness measures	Can reduce risk to life but will not prevent damage to the railway.	Yes	N/A	Discounted	Flood warning and preparedness measures would not address any of the failure modes							

5.1.3 Suitability Matrix and Long List Options

The Long List of Solutions have been cross-referenced against the failure modes addressed by each Solution and their suitability in addressing hazard exposure in each CCA sub-cell, as summarised in Table 5.5. Where the Solution can protect against the identified hazards for a given sub-cell, then it is marked as Y (Yes), thus identifying that it has the potential to be used as a Solution in that sub-cell. If the identified hazards are not present in a given sub-cell, then the Solution is marked as N (No) and it is not carried through as a viable Solution. These have enabled a Long List of Options (combinations of Solutions) for each CCA sub-cell to be identified.

The Long List of Options were then screened to discount options that will not meet the objectives or technical requirements for the given CCA sub-cell. The Long List of Options discounted across the CCA are provided in Table 5-6. The Long List of Options for each CCA sub-cell and reasons for discounting certain options in each sub-cell is provided in Table 5-7 to Table 5-11.

Table 5-5 Suitability matrix of long list solutions for each CCA sub-cell.

Long List Ref	Solution	Failure mode addressed by solution*							CCA6.1-A	CCA6.1-B	CCA6.1-C	CCA6.1-D	CCA6.1-E
		OT	ST	TS	BE	TE	GW	RF					
LL01	Do nothing								N/A	N/A	N/A	N/A	N/A
LL02	Do minimum								N/A	N/A	N/A	N/A	N/A
LL03	Relocation of the railway	✓	✓	✓	✓	✓	✓	✓	N	Y	Y	Y	Y
LL04	Detached Breakwaters - emergent rock or concrete armour units				✓				Y	Y	Y	Y	Y
LL07	Attached Breakwaters - rock			✓	✓	✓			N	N	N	N	N
LL08	Revetment - rock	✓	✓	✓		✓			Y	Y	Y	Y	Y
LL09	Revetment - concrete armour units		✓	✓		✓			N	Y	Y	Y	Y
LL11	Revetment - stepped concrete	✓	✓	✓					N	N	N	N	N
LL16	Toe Protection - rock			✓		✓			Y	N	N	Y	Y
LL18	Toe Protection - gabions			✓		✓			N	N	N	N	N
LL19	Toe Protection - steel sheet piles			✓		✓			N	N	N	N	N
LL21	Groynes - rock			✓	✓	✓			N	N	N	N	N
LL23	Vertical Seawall - concrete wall	✓	✓			✓			N	N	N	N	N
LL24	Vertical Seawall – sheet piles	✓	✓			✓			N	N	N	N	N
LL28	Set back flood wall	✓							Y	Y	Y	Y	Y
LL32	Beach Nourishment - beach recharge			✓	✓	✓			Y	Y	Y	Y	Y
LL35	Dune regeneration			✓	✓				N	N	N	N	N
LL44	Soft cliff stabilisation - shallow drainage systems						✓		N	N	N	N	N
LL45	Hard cliff stabilisation - rock netting							✓	N	N	N	N	N
LL46	Hard cliff stabilisation - rock bolting							✓	N	N	N	N	N
LL48	Hard cliff stabilisation - catch fences							✓	N	N	N	N	N
LL49	Rock fall protection - rock fall shelter							✓	N	N	N	N	N

*Note: OT - Wave overtopping; ST - Structural failure; TS - Toe scour; BE - Beach erosion; TE - Toe erosion; GW - Cliff failure through elevated groundwater levels; RF – Rock falls

Table 5-6 Long list options for CCA6.1 (general).

Sub-cell	Long List Options Greystones South to Newcastle
CCA6.1 General	Long list solutions discounted generally in CCA (with reason): • Concrete seawall incorporating greenway with piled foundations fronted by rock toe protection (LL23 with LL16) - significant increase in cost, encroachment and carbon in comparison with the non-greenway option) • Revetment – stepped concrete (LL11) - in comparison to rock solution requires larger footprint, higher back wall, toe protection, increased carbon, increased maintenance, has less future adaptation options and no residual material value at end of life • Groynes (LL21) – there is not sufficient longshore sediment transport for groynes to work without nourishment; would not prevent wave overtopping in future years • Dune regeneration (LL35) – would not provide sufficient protection in future years • Attached Breakwaters (LL07) – would not provide sufficient protection in future years • Toe protection – gabions and sheet piles (LL18, LL19) – does not improve SoP against wave overtopping and would provide limited protection to the existing structures, also not suitable as a deferment option due to limit reuse in long term scheme • Vertical seawall – concrete wall (LL23) – significant cost and carbon impact • Vertical seawall – sheet piles (LL24) – significant cost and carbon impact, would increase beach erosion • Soft cliff stabilisation – shallow drainage systems (LL44) – not applicable at CCA6.1 • Hard cliff stabilisation - rock netting (LL45) - – not applicable at CCA6.1

Table 5-7 Long list options for CCA6.1 - A for Greystones.

Sub-cell	Long List Options - Greystones
CCA6.1- A Greystones	1. Do nothing (LL01) 2. Do minimum (LL02) 3. Rock Revetment (with wave wall where needed) (LL08) 4. Detached breakwaters with beach nourishment and concrete splash wall where required (LL04 + LL32 + LL28) 5. Toe protection – rock (LL16) Deferment options • Deferral of rock revetment in northern section of CCA6.1-A with localised toe protection rock and beach nourishment Long list solutions discounted for this specific location (with reason): • Railway Relocation (LL03) • Concrete armour unit revetment (with wave wall where needed) (LL09)

Table 5-8 Long list options for CCA6.1- B for Cobblers Bulk.

Sub-cell	Long List Options - Cobblers Bulk
CCA6.1- B Cobblers Bulk	1. Do nothing (LL01) 2. Do minimum (LL02) 3. Railway Relocation (LL03) 4. Rock Revetment (with wave wall where needed) (LL08) 5. Concrete armour unit revetment (with wave wall where needed) (LL09) 6. Detached breakwaters with beach nourishment and concrete splash wall where required (LL04 + LL32 + LL28) Deferment options • No options for deferring as existing structures all require rebuilding to provide the required SoP Long list solutions discounted for this specific location (with reason): • Rock toe protection to vegetation (LL16) (would not provide sufficient protection)

Table 5-9 Long list options for CCA6.1- C for Kilcoole.

Sub-cell	Long List Options - Kilcoole
CCA6.1- C Kilcoole	1. Do nothing (LL01) 2. Do minimum (LL02) 3. Railway Relocation (LL03) 4. Rock Revetment (with wave wall where needed) (LL08) 5. Concrete armour unit revetment (with wave wall where needed) (LL09) 6. Detached breakwaters with beach nourishment and concrete splash wall where required (LL04 + LL32 + LL28) Deferment options • No options for deferring as existing structures all require rebuilding to provide the required SoP Long list solutions discounted for this specific location (with reason): • Rock toe protection to vegetation (LL16) (would not provide sufficient protection)

Table 5-10 Long list options for CCA6.1- D for Cooldross (north of The Breaches).

Sub-cell	Long List Options – Cooldross
CCA6.1- D Cooldross	1. Do nothing (LL01) 2. Do minimum (LL02) 3. Railway Relocation (LL03) 4. Rock Revetment (with wave wall where needed) (LL08) 5. Concrete armour unit revetment (with wave wall where needed) (LL09) 6. Detached breakwaters with beach nourishment and concrete splash wall where required (LL04 + LL32 + LL28) Deferment options • Defer option to 2100 by installing rock toe protection to vegetation to reduce erosion. Rock can then be reused in revetment or breakwaters Long list solutions discounted for this specific location (with reason): • Not applicable.

Table 5-11 Long list options for CCA6.1- E for Newcastle North (south of The Breaches).

Sub-cell	Long List Options – Newcastle North
CCA6.1- E Newcastle North	1. Do nothing (LL01) 2. Do minimum (LL02) 3. Railway Relocation (LL03) 4. Rock Revetment (with wave wall where needed) (LL08) 5. Concrete armour unit revetment (with wave wall where needed) (LL09) 6. Detached breakwaters with beach nourishment and concrete splash wall where required (LL04 + LL32 + LL28) Deferment options • No options for deferring as overtopping analysis suggests 0.5%AEP threshold is already exceeded Long list solutions discounted for this specific location (with reason): • Rock toe protection to vegetation (LL16) (would not provide sufficient protection)

5.2 Short List of Options

The technically feasible sub-cell Long List of Solutions that were screened and taken forward from the previous stage (Section 5.1) are combined and presented as a Short List of Options on a CCA-wide basis. In many cases these options have the same solution applied across all sub-cells, but in other cases they comprise different solutions between the sub-cells. Where various combinations of solutions are grouped together, these have been combined based on engineering judgement to provide a coherent and complimentary approach for the overall cell.

The Short List of Options for the overall CCA are presented in (Table 5-12). This list includes the Do Nothing option (no works, including no maintenance) as Option 1 and the Do Minimum option (allows for reactive maintenance only) as Option 2.

Option 3 (Relocation of the railway line away from the coast) has been removed from the short list options due to the significant cost and absence of policy associated with relocation of the railway line compared to the other short-listed options hence no further analysis has been carried out. Options 1 and 2 do not meet the Project objectives but are included to serve as baseline options against which the strategic and planned upgrade of defences is delivered through the Project.

All remaining “Do Something” options (Options 4 to 9) meet the scheme objectives, the requirements for design life and provide the required Standard of Protection.

As presented in Table 5-12, only Options 4 and 6 include the same solution across all sub-cells. All other options include a combination of solutions most appropriate to each sub-cell. Options 7 and 8 include solutions from Option 4 and 5 respectively combined with Option 6 to include detached breakwaters where there are healthier, more stable beaches and revetments in the more vulnerable areas (typically where rock revetments already exist to manage risk). Option 9 includes revetments in the more vulnerable locations and rock berms in the locations where there is no immediate risk to the railway. The rock berms are a short to mid term solution to prevent shoreline erosion, but it is anticipated that these structures may need to be upgraded to full rock revetments in the future to manage climate change risk to the railway line.

Table 5-12 Overview of short list options for CCA6.1.

Option	CCA6.1 – A Greystones	CCA6.1 – B Cobblers Bulk	CCA6.1 – C Kilcoole	CCA6.1 – D Cooldcross	CCA6.1 – E North Newcastle
1. Do Nothing	N/A	N/A	N/A	N/A	N/A
2. Do Minimum	Do Minimum	Do Minimum	Do Minimum	Do Minimum	Do Minimum
4. Rock Revetment (with wave wall where needed)	Rock Revetment with wave wall where required	Rock Revetment with wave wall where required	Rock Revetment with wave wall where required	Rock Revetment with wave wall where required	Rock Revetment with wave wall where required
5. Concrete Armour Unit Revetment (B to C) Rock Revetment (A, D and E)	Beach nourishment with splash wall and/or rock in localised areas	Concrete Armour Unit Revetment	Concrete Armour Unit Revetment	Rock Revetment	Rock Revetment
6. Detached breakwaters with beach nourishment and concrete splash wall where required	Detached breakwaters with beach nourishment and concrete splash wall where required	Detached breakwaters with beach nourishment and concrete splash wall where required	Detached breakwaters with beach nourishment and concrete splash wall where required	Detached breakwaters with beach nourishment and concrete splash wall where required	Detached breakwaters with beach nourishment and concrete splash wall where required
7. Detached breakwaters with beach nourishment and concrete splash wall where required (A, D and E) Rock revetment (B and C)	Beach nourishment with splash wall and/or rock in localised areas	Rock Revetment with concrete wave wall	Rock Revetment with concrete wave wall	Detached breakwaters with beach nourishment and concrete splash wall where required	Detached breakwaters with beach nourishment and concrete splash wall where required
8. Detached breakwaters with beach nourishment and concrete splash wall where required (A,D and E) Concrete armour revetment (B and C)	Beach nourishment with splash wall and/or rock in localised areas	Concrete armour Revetment with wave wall	Concrete armour Revetment with wave wall	Detached breakwaters with beach nourishment and concrete splash wall where required	Detached breakwaters with beach nourishment and concrete splash wall where required
Phased options (this relates to developing a long term strategy where deferred interventions are planned and considered part of the Short List Option):					
9. Rock Revetment with Adaptive Management at lower risk areas with rock toe protection (reverts to Option 4 for 2100 scenario)	Defer Beach nourishment with splash wall and/or rock in localised areas until needed (expected in 2055)	Rock revetment (no deferment)	Rock revetment (no deferment)	Rock toe protection to vegetation to reduce erosion. Rock can be reused (if needed) in revetment or breakwaters in year 2055 (or later)	Rock toe protection to vegetation to reduce erosion and concrete wave wall to limit overtopping. Rock can be reused (if needed) in revetment or breakwaters in year 2055 (or later)

5.3 Multi-Criteria Analysis

Following the development of the Short List of Options, an MCA was carried out to identify the Top-Ranking Short List Options to be brought forward to concept design.

The MCA identified the key risks, opportunities, advantages and disadvantages for each of the Short List of Options .As outlined in Section 3.6.1, the MCA contains seven core criteria which are further broken down into sub-criteria.

All options were assessed using the criteria in Table 3-2. Section 5.3.1 provides a summary of the outcome from the detailed MCA analysis. The full MCA sheet can be found within Appendix D.

5.3.1 MCA Outcomes

5.3.1.1 Economy

5.3.1.1.1 Land-Take

Options 1 & 2 have a significant advantage over other options as they do not propose any works which would impact on third party land or incur property costs.

Options 4-9 are comparable to each other as they all have significant disadvantages as there would be impacts on third-party lands.

5.3.1.1.2 Capital Expenditure

Option 1 & 2 have significant advantages over other options as they require no to minimal capital costs respectively. Option 9 has significant advantages over other options as it requires significantly less volumes of rock and all construction works could be land-based (except material delivery).

Options 4 has some advantages over other options as all construction could be land based (except material delivery).

Options 5 & 7 have some disadvantages over other options. Option 5 requires on site fabrication of the concrete armour units which requires significant handling constraints and specialist contractors/equipment. Option 7 requires a significant amount of material to construct the breakwaters. Specialist marine plant is required for both the breakwater construction and the beach nourishment (requires dredging and pumping ashore). Both options score better than Options 6 & 8 as they have a smaller footprint of beach nourishment and breakwaters.

Options 6 & 8 have significant disadvantages over other options as they propose extensive marine based construction. Both options require a significant amount of beach nourishment which would need to be dredged and pumped ashore. Both options require a significant amount of material for the breakwaters and both options have elements of concrete structures.

5.3.1.1.3 Maintenance Expenditure

Option 1 has a significant advantage over other options as it requires no maintenance works. Option 4 has a significant advantage over other options as only infrequent maintenance will be required. Should repair works be needed, this could reasonably be carried out from the beach which would negate the need for any specialist/marine based plant.

Option 5 has some advantages over other options as although maintenance will be infrequent, the complexity of maintenance required for the concrete armour revetment would increase costs in comparison to maintaining rock revetments. Option 7 has some advantages over other options as although it proposes similar structures as Option 6, there are less breakwaters and beach to maintain.

Option 8 is similar to Option 7 but it has further disadvantage due to the complexity and increased costs of maintaining the concrete armour revetment. Option 9 has some disadvantages as it is likely to require more frequent maintenance to the defences as they reach the end of their design life.

Option 2 would have a significant disadvantage as works proposed are ad hoc and emergency repairs which are difficult to plan and typically cost inefficient. Option 6 has a significant disadvantage over other options due to the increased scale of beach maintenance required and the number of breakwaters (both marine based activities). Frequent monitoring and regular maintenance of the beach nourishment would also be required.

5.3.1.2 Safety

5.3.1.2.1 Health & Safety (Construction)

Option 1 has a significant advantage over other options as no construction works would take place. Options 4 & 9 have significant advantages over other options as the rock armour can be handled by less-risky land-based plant (following marine material delivery).

Option 5 has some disadvantages over other options as there is a significant risk due to transportation and handling of concrete armour units on both land and marine-based handling and transport. Works would be required within open water and relies on marine based works. Option 7 has some disadvantages over other options due to requirement of specialist marine equipment and contractors to construct the detached breakwaters. Option 7 would also be challenging to construct in open water and would require stockpiling of material on land and marine areas. Option 8 is similar to Option 7 but with the addition of a concrete armour revetment. These structures are generally heavy and challenging to construct, transport and place.

Option 2 has significant disadvantages over other options as it relies on unplanned emergency repair works in a difficult coastal environment, which typically carries a higher risk than planned works. Option 6 has significant disadvantages over other options as it requires construction of a large number of breakwaters in open water that require exclusive marine equipment which has increased safety risks. Works for the concrete seawall will take place adjacent to the railway line which would increase the construction health & safety risk.

5.3.1.2.2 Health & Safety (Design Life)

Options 4, 5, 6 & 9 have some advantages over other options. For operational health and safety, there is a risk of the public walking/climbing on the revetments for Options 4, 5 & 9. There is also the potential for the revetments to reduce the usable area of the beach which could lead to members of the public being cut off by the tide, but this can be mitigated by providing access points through the revetments. Option 6 stabilises a beach to provide safer public access and improved, safer areas for amenity. However, this is offset by the added risk of the public swimming out to the detached breakwaters where complex currents could pose additional risks.

Option 2 has some disadvantages over other options as it proposes reactive, emergency works to repair the existing defences. These would not be planned, and it could lead to periods of time where there is health and safety risks prior to the works being carried out. As there are no improvement/upgrades proposed as part of this option, events such as overtopping and flooding onto the railway may increase which poses public health and safety risks. Option 7 & 8 have some disadvantages over other options as they combine proposals from Options 4 and 6 which combines the same risks from each of these options.

Option 1 has significant disadvantages over other options as no interventions are proposed. This could result in failure of the existing defences and impacts on the railway and the publicly accessible areas rendering them unsafe.

5.3.1.3 Accessibility & Social Inclusion

5.3.1.3.1 Community

Option 6 has significant advantages over other options. Option 6 proposes an enhanced beach amenity area along the coastline which will contribute positively to the local area.

Options 7-9 have some advantages over other options. They have similar advantages to Option 6 in relation to amenity beach enhancement. However, the addition of rock revetments will impact on the usable beach area.

Option 2 would have some disadvantages over other options as it proposes reactive repair works which would result in further erosion and damage to areas used by the public and an impact on operational train services.

For Options 4 & 5, the placement of rock/concrete revetments along the coastline would restrict the use and amenity value of the existing beach area.

Option 1 has significant disadvantages over other options for community. Under this option, no works would be proposed which could result in continued coastal erosion and potential impacts to the rail line and access to the amenity beach area. This could prevent the beach area being used in the future.

5.3.1.3.2 Access

Option 6 has significant advantages over other options. Option 6 proposes an enhanced beach amenity area and will not impact on any existing access points to the beach. Splash wall locations will be limited and therefore impacts on access will also be limited.

Options 7-9 have some advantages over other options. While hard structures that are proposed as part of these options may cause an imposition on the beach area, access points will be built into these structures to ensure access points are not impacted.

Option 2 would have some disadvantages over other options as it proposes reactive repair works. This would result with continuous erosion of the beach and eventually the footbridge structures behind the beach would become unviable, leading to a severance of alongshore access.

Option 1 has significant disadvantages over other options for access. Under this option, no works would be proposed which would result in continued coastal erosion and direct impacts to the rail line and access to the amenity beach area.

5.3.1.3.3 Social & Recreational Facilities

Option 6 has significant advantages over other options through the provision of an enhanced beach amenity area along the coastline, which will contribute positively to the local area.

Options 7-9 have some advantages over other options. For all options, the placement of hard structures may impact the usable beach amenity area which could have an impact on recreational use of the beach.

Option 2 would have some disadvantages over other options as it proposes reactive repair works. This would result with continuous erosion of the beach and will result in the loss of the amenity beach area. For both options 4 & 5, placement of rock/concrete revetments along the coastline would restrict the use and amenity value of the existing beach area.

Option 1 has significant disadvantages over other options for recreational use. Under this option, no works would be proposed which could result in continued coastal erosion and direct impacts to the rail line and access to the beach area.

5.3.1.4 Integration

5.3.1.4.1 Compatibility with Development Plans

Option 9 has some advantages over other options as it would enhance the beach and recreation amenity, which is broadly in line with the aims and objectives of the Wicklow Development Plan. Option 9 also includes green infrastructure which is again consistent with the development plan. Option 9 has less intrusive engineering structures in the short/medium term and consequently less impacts in comparison with other options.

Option 2 has some disadvantages as it does not provide coastal zone management and coastal area protection that are identified as important within the relevant development plans. The disadvantage relating to this option is that the minimum works rely on ad-hoc repairs, it would not fully achieve the objectives of the development plan. Options 4 & 5 have some disadvantages over other options as they have the potential to impact protected areas such as indicative green route, prospects and European Designated Sites. Options 6, 7 & 8 have some disadvantages as they have the potential to impact on Marine Policy / Map Based objectives as they proposed marine structures such as detached breakwaters. While Options 6, 7 & 8 have the potential to enhance the amenity beach area through nourishment, the impacts on biodiversity and landscape result in some disadvantages over Option 9.

Option 1 has significant disadvantages over the other options. The policy within the relevant development plan identifies coastal zone management and protection of the coast as important. This option does not provide any coastal protection or protection for the railway line and therefore is not in line with the aims and objectives of the Wicklow Development Plan. Option 1 does not address the issue of climate change which is an overarching concern across high level planning policy.

5.3.1.4.2 Compatibility with Climate Plans

Option 9 has significant advantages over other options. This option has some advantages it generally aligns with Transport Climate Change Sectoral Adaptation Plan (TCCASP) in terms of protecting the coastline and transport assets.

Option 4 has some advantages over other options. It aligns with the TCCSAP by protecting the existing rail infrastructure through a complete upgrade of existing defences. However, it would also involve a significant volume of materials for the rock revetments to be brought to site and transport of same.

Option 2 has some disadvantages over other options. Coastal zone management and coastal area protection are identified as important within the Wicklow Development Plan. The disadvantage relating to this option is that the minimum works rely on repairs, not a full upgrade would not fully achieve the objectives of the plans which include the need for climate adaptation. The Climate Action Plan 2023 sets out under 15.3.6 (Adaptation) the challenges related to the operation and resilience of the inter alia the rail network. There is a need to go beyond 'patching up' and to prepare for current and future change. While Option 5, 6, 7 and 8 align with the TCCSAP by protecting the existing rail infrastructure, they require a significant volume of materials for the hard structures which is a disadvantage in terms of carbon footprint.

Option 1 has significant disadvantages over the other options. Do nothing would contravene climate objectives such as *Eastern and Midlands Region RSES "RPO 7.3 EMRA will support the use of Integrated Coastal Zone Management (ICZM) to enable collaborative and stakeholder engagement approaches to the management and protection of coastal resources against coastal erosion, flooding and other threats."*

5.3.1.4.3 Compatibility with Transport Plans

Options 4, 5, 6, 7, 8 and 9 have significant advantages over other options as they will improve the protection of the rail line against climate change impacts, in line with the Transport Strategy's aim to "provide a sustainable, accessible and effective transport system for the Greater Dublin Area which meets the region’s climate change requirements, serves the needs of urban and rural communities, and supports economic growth". The Greater Dublin Area Cycle Network Plan proposes a National Cycle Route, the East Coast Trail, with an indicative route along part of the coastline between Greystones and Wicklow Town. Providing the intervention works can accommodate the East Coast Trail, this option will support the Transport Strategy.

Option 2 has some disadvantages it is expected to involve disruptions to public transport in the short to medium term to conduct repairs as the need arises. The ad hoc repairs will address damage that may occur but won't build longer-term resilience against potential impacts of flooding or erosion. As per Do Nothing, this is likely to put increasing pressure on the public transport system and challenge its reliability, going against the Transport Strategy's focus on facilitating increased use of sustainable modes.

Option 1 has significant disadvantages over the other options. The NTA's Greater Dublin Area Transport Strategy 2022-2042 outlines the need to ensure resiliency of the public transport network to climate change effects, and specifically mentions potential flooding along the Dublin and Wicklow coastline. Do Nothing will mean no interventions being made to prevent flooding and coastal erosion, which may becoming increasingly frequent events in the future. While there may be little short-term impact, in the longer term this will put increasing pressure on the public transport to accommodate passengers displaced from rail services. Disruptions to the rail service may result in an unreliable public transport system, causing a mode shift to car travel rather than public transport. This goes against the Transport Strategy's focus on facilitating increased use of sustainable modes.

5.3.1.5 Environment

5.3.1.5.1 Biodiversity

In the short to medium term Option 1 will provide significant advantages over other options because there would be no construction work and therefore, no resulting biodiversity loss, degradation or disturbance (noise/pollution). European and nationally designated species and habitats would avoid the construction and operational effects that come with other options and natural processes would be able to proceed unconstrained.

Option 2 has some advantages as there is less impacts from the targeted construction works. In the short to medium term these potential effects will be less so than the following options which require a greater magnitude of construction. However, both options 1 and 2 present greater issues in the long term than other options. This is due to the habitat loss that will occur due to unmanaged coastal erosion and wetland exposure to tidal action. There is also the potential that the existing rail line could release embedded oils and contaminate the shore and sea.

Options 4 & 5 have some disadvantages over other options. Construction impacts as a result of night-time works and potentially noisy construction works have the potential to impact on sensitive ecological receptors. Access for these options has the potential to be restricted and therefore there is a potential reduced in impacts of recreational activities on sensitive ecological features. Option 9 has similar impacts to 4 & 5 however access would not be impacted.

Options 6-8 have significant disadvantages over other options. Similar to 4, 5 & 9, there is a requirement for night time works and transportation of materials by barge. Options 6, 7 and 8 have increased long-term disturbance due to future beach nourishments and an increase in footfall on the beach due to an increase in amenity beach area.

Options 4-9 have the potential for operational effects including a loss of QI species and habitats underneath developments and potential erosion due to changes in hydrology.

5.3.1.5.2 Landscape, Visual & Seascape

Option 9 has significant advantages over other options due to rock revetments being a natural material that will mirror the natural qualities of the coastline. Material placement will be robustly considered in terms of scale and uniformity and so will enhance the already existing features of the coastline.

Option 4 has some advantages over other options as while it is similar to the proposals in Option 9, it requires a larger footprint for the rock revetments which is a slight disadvantage.

The other options have disadvantages for a variety of reasons; including, material use that does not blend seamlessly with the coastlines natural qualities (Options 5 & 8), use of detached breakwaters (Options 6, 7 & 8) and reactive intervention that deals with problem areas as they occur resulting in a patchwork of responses (Option 2). Option 1 has significant disadvantages over all other options because allowing coastal erosion to continue at the current rate will result in significant deterioration of the coastal landscape as the railway line is eventually abandoned and existing defences fail.

5.3.1.5.3 Archaeology, Architectural & Cultural Heritage

Options 4, 5, 6, 7, 8 & 9 are comparable to each other. They have no potential to directly or indirectly impact the identified SMR sites. Potential indirect setting and visual impacts to four NIAH and three RPS sites. Unrecorded material culture and archaeological heritage if present on site has the potential to be directly impacted by these options.

Options 1 and 2 have significant disadvantages over all ‘do something’ options. Option 2 has slight advantages over option 1 due to reactive interventions which seek to repair the coastline. Allowing continued disruption to the coastline through doing nothing or reactive interventions would cause significant adverse effects to archaeology, architectural and cultural heritage sites.

5.3.1.5.4 Marine Archaeology

Options 1, 2, 4 & 9 have significant impacts over other options as they do not propose works or permanent structures within the marine and intertidal areas.

Options 5, 7, 8 have some disadvantages in relation to impacts on marine archaeological features. Beach nourishment employs the use of dredgers to replenish the beach which has the potential to significantly directly impact marine archaeology features. Potential direct impacts have also been identified from the presence and construction of detached breakwaters (Options 7 & 8) within the sub-tidal areas.

Option 6 has significant disadvantages over other options as it has a significantly larger marine footprint and therefore has more potential to impact on previously unrecorded wrecks, paleoenvironmental landscapes and material culture both within the sub-tidal areas within the footprint of the breakwaters and beach nourishment dredging and pumping.

5.3.1.5.5 Noise & Vibration

Options 4-9 are comparable against each other. There will be temporary and short-term impacts due to construction but no long-term operational impacts. Short-term construction noise from the mobile plant in CCA6.1 A&B will be localised and temporary. All options other than Option 4 will require repeated/frequent works. The remainder of construction works will take place away from NSLs and so will have less impact. Options 6,7 and 8 include construction of detached breakwaters which will cause underwater noise. Construction of rock toe protections in Option 9 will cause higher noise pollution than the other construction works options, however, this construction will exclusively take place in areas with a low density of NSLs. None of the options will cause significant vibrational impacts.

Options 1 & 2 have some disadvantages over the other options. While they do not propose any construction work, there is an increased likelihood of a less reliable/disrupted rail network after storm events or loss of the railway. This will potentially increase road traffic levels and therefore transport related noise levels in the surrounding communities.

5.3.1.5.6 Air Quality

All 'do-something' options will have a long-term positive operational impact due to maintaining the existing rail line and so reducing reliance on private vehicles.

Option 4 has significant advantages over other options because although construction impacts are predicted such as vehicle emissions and dust, there is no ongoing maintenance required so this will be short-term in nature.

Options 5 & 9 have some advantages over other options. These options require the use of heavy machinery in the construction of coastal protection measures and so noise impacts will be present. They propose similar machinery to other options, but as they do not propose beach nourishment this has reduced impacts compared to Options 6-8.

Options 6, 7 & 8 have some disadvantages over other options. They propose similar heavy machinery to Options 5 & 9 however, they require ongoing monitoring and maintenance of beach nourishment which increases the potential dust emissions; however, these can be reduced through mitigation measures.

Options 1 and 2 have significant disadvantages over all other options due to the potential for long-term operational impacts that would occur as a result of the rail line being disrupted/suspended. Option 2 also has some potential dust and air pollution impacts as a result of general construction of ad-hoc emergency works.

5.3.1.5.7 Carbon Management

Options 4-9 facilitate operational phase reliance on public transport and reduce reliance on private vehicles for the long term.

Option 9 has significant advantages over other options as it has the lowest Whole Life Carbon (tonnes CO_2e) of all options.

Options 4, 5, 6 & 7 have some advantages over other options as they have preferable levels of Whole Life Carbon (tonnes CO2e) compared to other options.

Option 8 has some disadvantages over other options as is has unfavourable levels of Whole Life Carbon (tonnes CO2e) compared to other options.

Options 1 & 2 have significant disadvantages over other options. Both options have low GHG emissions from embodied carbon due to no/minimal construction repair works. However, long-term operation phase impacts may occur as a result of rail line suspensions. Both potential operational impacts would result in increase in local traffic numbers.

5.3.1.5.8 Water Resources

Options 1, &2 have a significant advantage over other options. Option 1 requires no construction work and therefore no impact on ground water. Option 2 would have minimal construction work with negligible impacts on groundwater.

Option 4 to 9 are all similar as they should have minimal impact on the water resources.

5.3.1.5.9 Geology & Soils

Options 4 & 9 have some advantages over other options. Both options comprise of rock revetment with wave walls which will result in minimal/moderate disturbance to geology and remobilisation of ground-contamination. Option 4 has these features throughout CCA6.1 and Option 9 in CCA6.1-A and CCA6.1-D. Rock toe protection proposed in Option 9 will have minimal disturbance to geological resources and ground contamination.

Options 2, 5, 6, 7 & 8 have some disadvantages to other options. Although in the short-term Option 2 has no significant impacts, in the medium to long term frequent works will be required to address erosion. Option 5, 6, 7 & 8 include varying magnitude of beach nourishment which is predicted to cause moderate disturbance to geological resources and potential remobilisation of contamination. Option 5 involves instillation of rock revetment which is predicted to cause minimal/moderate disturbance. Options 5 & 8 involve concrete armour revetment which is predicted to cause moderate/high disturbance. Options 6, 7 & 8 require concrete splash walls which are predicted to cause moderate disturbance and have the potential for remobilisation of contamination. The installation of a detached breakwater for Option 6 at CCA6.1-A may result in remobilisation of contaminated materials from a historic dredged material disposal site.

For Option 1 there are significant disadvantages compared to other options. While there will be no impacts in the short term, the medium to long term climate change may cause erosion of the local geology.

5.3.1.5.10 Materials & Circular Economy

Options 1, 2, & 4 have significant advantages over other options as they all have the lowest materials consumption score compared to other options.

Options 5 & 9 have some advantages over other options as they have a lower materials consumption score compared to other options.

Options 7 & 8 have some disadvantages as they scored a high materials consumption score compared to other options.

Option 6 has significant disadvantages over other options as it scored a very high materials consumption score compared to other options.

5.3.1.5.11 Waste

Options 1 & 2 have significant advantages over other options as no waste would be generated due to no/minimal works proposals.

Option 9 has significant advantages over other options as minimal waste would be generated from removal of existing structures and it has a comparatively low wastage potential. Most waste can be re-used for primary functions and so it has an advantage over Options 4, 6 & 7.

Options 4, 6 & 7 have some advantages over other options as minimal waste would be generated from removal of existing structures and they have comparatively low wastage potentials.

Options 5 & 8 have some disadvantages over other options as they have comparatively high wastage potentials and there is less opportunity for beneficial re-use of the existing rock on the frontage.

5.3.1.5.12 Traffic & Transport

Options 4-9 are comparative as minimal operational impact expected to traffic & transport; the intervention works will be localised to the coast and are not anticipated to affect transport systems or travel demand.

Option 2 has some disadvantages as disruptions to transport may be likely due to the requirement for ad-hoc repairs. This may lead to impacts on local roads with increased private car use and over-crowding on bus services.

Option 1 has significant disadvantages over other options as there is potential for significant impacts on rail services, within this CCA the road network is further inland than the rail line. This may lead to impacts on local roads with increased private car use and over-crowding on bus services.

5.3.1.6 Engineering

5.3.1.6.1 Constructability

Option 1 has a significant advantage over other options as it does not propose any construction works.

Option 4 has some advantages over other options as it requires a significant amount of rock material to construct. Option 9 has significant advantages as it proposes a deferral of works which may allow rock to be sourced locally. Construction for both options is relatively simple but would be slow. Several work fronts could be opened up to improve construction duration. As existing infrastructure is being added to rather than removed and the cross section is relatively constant throughout the length of the CCA, this option would be simpler to construct. Once delivered to the beach through marine offload, the rock armour can be handled entirely by land based plant.

Options 2, 5, 6, 7 & 8 have some disadvantages over other options. Options 6, 7 & 8 require significantly more materials and require difficult marine work to construct the breakwaters. Option 2 has some disadvantages as it proposes emergency works only. Options 5 & 8 have some disadvantages as it proposes concrete armour revetment which requires specialist plant and experience. Construction of these structures are complex.

5.3.1.6.2 Rail Service Impact

Option 1 has a significant advantage as no works are proposed.

Options 4-9 are comparable to each other as the operation of railway line will be minimally impacted as the works are adding to existing infrastructure so no extended disruptions to the rail service is needed. Irish Rail will require to be notified of works as adjacent to the railway line, but this is expected to be low risk.

Option 2 has some disadvantages over other options as ad-hoc emergency works may impact the railway line.

5.3.1.6.3 Reliance on Maintenance

Option 4 & 5 have significant advantages over other options as they require minimal maintenance during their design life.

Options 7 & 8 have some advantages over other options. Both options propose beach nourishment, which requires regular monitoring and post-storm inspections to inform future beach renourishment needs, but there is less reliance on nourishment that some of the other options. Both options may require more regular repairs compared to concrete seawalls and a concrete armour revetment for Option 8.

Option 1 has some disadvantages over other options as although there is no requirement for maintenance, monitoring would be required to keep the public safe. Options 6 & 9 also have some disadvantages. Option 6 has similar disadvantages as Options 7 & 8 in relation to monitoring and maintenance of concrete structures however the increased reliance on beach levels will require further ongoing monitoring and maintenance of beach nourishment. For Option 9, the rock revetments would require a routine and post-storm monitoring plan but would require minimal maintenance through its design life. However, the deferment in would require regular monitoring within the first 25 years.

Option 2 has significant disadvantages over other options as it relies heavily on monitoring and reactionary maintenance and repairs.

5.3.1.6.4 Adaptation

Option 9 has a significant advantage over other options as it allows for future adaptation as the main works are not implemented until 2055.

Options 4, 6, 7 & 8 are comparable to each other as all designs allow for future adaptation. Rock structures can be added to, or simply rebuilt to a new geometry. Options 6, 7 & 8 allow for future variations in the beach levels (hence levels of protection) through the renourishment works. However, wall raising could be challenging.

Option 5 has some disadvantage as adapting the concrete armour unit revetments is difficult.

Option 1 & 2 have significant disadvantages over other options as there is no works/minimal works proposed and therefore limited opportunity for adaptation.

5.3.1.6.5 Residual Risk

Options 4, 5 & 9 are comparable to each other as they use hard engineering structures along the shoreline to provide the standard of protection. Failure of revetments is typically slow and progressive so sudden failure would not be expected.

Option 6 has significant advantages as it includes detached breakwaters which would reduce the wave energy before it reaches the shoreline, combined with beach nourishment.

Options 7 & 8 have some advantages as they include detached breakwaters in some sections which would reduce the wave energy before it reaches the shoreline, combined with beach nourishment. These options have some disadvantaged compared to Option 6 as they include revetments in some section.

Option 2 has some disadvantages over other options as small scale, localised repairs can manage risk. However, this is not a long-term option.

Option 1 has a significant disadvantage over other options as no works would occur. This would lead to a degradation of existing defences potentially leading to a catastrophic event.

5.3.1.7 Planning Risk

In regard to planning risk, Options 1 and 2 have significant advantages over the other options as they would require little or no planning consents and consequently no or limited planning risk.

Option 9 has some advantages over other options as the proposed upgrade to the coastal defences align with planning policy for long term protection against the backdrop of climate change. The works are likely to be carried out within a Natura 2000 Site, but to a lesser extent than other options due to a smaller works footprint. The potential for IROPI increases the planning risk as it will increase the chances that the option will either be refused permission or significantly delayed in its determination. Option 9 scores higher for integration (landscape) than any other option and has a high score in regard to amenity which could reduce the likelihood of third party objection.

Options 4 and 5 have some disadvantages over other options. The proposed works are within Natura 2000 Site with potential for temporary and permanent impacts on qualifying interests which could invoke IROPI leading to delay and/or greater chance of permission being refused. Options 4 and 5 score poorly for biodiversity and amenity which has the potential to increase third party objection. Option 5 also scores poorly for landscape and a lack of integration is also likely to attract objection. .

Options 6, 7 and 8 have significant disadvantages over other options. The proposed works have a large footprint and are carried out in Natura 2000 sites with potential to require IROPI leading to increased potential for delay and refusal of planning permission. Options 6, 7 and 8 score poorly for biodiversity and landscape, increasing the potential for objection.

5.3.2 Summary

A summary of the MCA outcomes are shown in Table 5-13. Options 4 & 9 have been identified as the Top-Ranking Short List Options to be taken forward. The basis for each of these options are as follows:

- Option 4 ranks the joint highest with Option 9 for Safety, Engineering and Environment. Option 4 has comparative advantages for Economy and Integration. This Option scored comparable to other options for Accessibility & Social Inclusion and for Planning Risk.
- Option 9 was the highest ranked option for Integration and was joint top with Option 4 for Safety, Environmental and Engineering. Option 9 had comparable advantages for Economy, Accessibility & Social Inclusion and Planning Risk.

These two options will be discussed further in Section 5.4 to identify the Emerging Preferred Option for this CCA.

Table 5-13 Short list MCA outcomes summary

	Option 1	Option 2	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
Economy								
Safety								
Accessibility & Social Inclusion								
Integration								
Environmental								
Engineering								
Planning Risk								

5.4 Top-Ranking Short List Options

The initial optioneering stage (Sections 5.1 & 5.2) identified the Short List of Options from the Long List of Options. The MCA stage (Section 5.3) then identified the two clear top-ranking options from the Short List of Options. For clarity, these Top-Ranking Short List of Options have been re-named as Options A and B and are summarised as follows:

- Option A: Rock Revetment (with raised wall where needed) (Short List Option 4)
- Option B: Defer Option through rock toe protection to vegetation and setback floodwall with full rock revetments being constructed in approximately year 50 (Short List Option 9)

These options all meet the scheme objectives, the requirements for design life and provide the required Standard of Protection. The options all adopt a "Hold the Line" approach by protecting the shoreline on its current alignment using upgraded defences to improve the Standard of Protection.

The two Top-Ranking Short List Options (Options A and B) are described in outline within this section and Appendix E provides concept design drawings of each option. These options were progressed to Concept Design level and have been modelled and costed. This section presents the engineered solutions, summarises the modelling and costing analysis and identifies the Emerging Preferred Option (EPO).

5.4.1 Concept Designs

The concept designs for each of the Top-Ranking Short List Options considers the following:

- Wave climate and extreme water level data for initial analysis has been extracted from detailed hydrodynamic modelling outputs undertaken during Phase 2 of the Project;
- Initial analysis of wave overtopping rates during storm events has been undertaken using EuroTop formulae. This analysis includes an allowance for sea level rise. This analysis informs the required geometry of the improved defences to provide the required Standard of Protection (0.5% Annual Exceedance Probability, also known as a 1 in 200 year storm protection level);
- Initial rock stability calculations have been undertaken using the Van Der Meer methods. This informs the required rock grading to ensure stability of the rock armour to provide the required Standard of Protection;
- The condition of the existing coastal defences has been informed by the visual dilapidation survey undertaken during Phase 2 of the Project;
- Defence type and material selection have been selected to meet the design life and to minimise future maintenance requirements;
- Constructability and technical viability have been considered in the design to ensure the options are feasible;
- Within the bounds of each option form, the impact on the environment and community have been minimised where possible; and
- Health and safety risks during construction and to the public following construction have been considered.

The design work undertaken for the concept design is sufficient to confirm that the options will work from a technical perspective and provide the required SoP for the design horizon and allow comparison between the options. However, the following should be noted:

- All levels and dimensions are preliminary and based on initial concept level analysis. Designs are expected to change through design development (e.g., the size of the rock armour or the geometry of the revetment);
- Typically, only one cross section through each sub-cell has been prepared; as the design is developed there will be multiple cross sections to reflect the changes in the existing ground levels, existing structures and location of the railway line; and
- Details around access points and structures such as outfall and culverts have not been developed at this stage.

The following sections describe the concept designs for Option A and B and provides a commentary on the relative advantages and disadvantages for each option.

5.4.1.1 Option A

Option A comprises rock revetments and wave walls for the full coastal cell. These revetments will vary in form along the frontage relative to the wave exposure, foreshore type/level and to integrate with the various natural and man-made shoreline features.

The Option A concept design proposed for each of the sub-cells is summarised by Figure 5-1. This is further detailed by the concept design engineering drawings in Appendix E.

The addition of good quality rock around/over existing coastal defences to manage coastal flooding and erosion risk is commonplace. There are existing rock revetments within sub cells CCA6.1-B and CCA6.1-C to protect the railway line from flooding. The dilapidation survey showed that the general condition of these structures was poor and they should be rebuilt. In addition, concept design calculations indicated that the size of the structures is not sufficient to provide the required SoP over the design horizon to respond to climate change impacts. This is due to the revetments not being high enough to limit the wave overtopping onto the railway line and the grading of the rock armour (based on visual inspections only) is unlikely to be large enough for stability under the design wave conditions in the future.

The existing revetements will be dismantled and the rock will be reused within the new revetments where possible. As the rock armour in the existing revetments appears to be undersized and there is no information available on the quality of the rock (e.g., rock density, strength) which affects the suitability of the rock, it is assumed that most of the rock will be used within the underlayer or core of the new revetments where smaller rock is required and the rock properties (such as rock density) are less critical given the rocks are not exposed to direct wave action. In some locations it may not be necessary to remove all the rock from the existing revetments, for example if the underlayer or core rock is in condition and well-constructed then it might be possible to leave this in place and build over it with the new rock armour.

A wave wall is required at the back of the crest of the rock revetment to provide an impermeable barrier at the back of the revetment. The geometry of these walls will be determined through design development, in some instances the top of the wall might be level with the top of the rock armour but in other location the wave wall might extend above the rock armour. This will depend on the height required to limit the wave overtopping and the geometry of the existing ground profiles.

The toe of the rock revetments will be buried beneath the existing ground levels, this is to minimise loss of beach/intertidal habitat and to allow for future foreshore levels to lower without the revetment becoming undermined. Further analysis into localised scour at the toe and predicted long term trends of the beach levels will be undertaken during design development to determine the level of the toe. An alternative detail would be to have an exposed toe that sits on top of the beach but is wider such that as the levels in front of the toe lower, the rock toe 'falls' into the hole whilst still providing support to the revetment. If the levels of the proposed toe design are considered to be problematic from a construction perspective, due to the depth of the toe compared to the water levels, then during design development the toe detail can be revised.

In CCA6.1-B, there is a section of approximately 500m where sheet piles are required at the rear of the revetment to provide the wave wall. This is due to limited space between the existing revetment and the railway line meaning it is not feasible to install and concrete wave wall.

At sub-cell CCA6.1-D, around The Breaches, Option A comprises a concrete revetment with rock toe protection. This is because The Breaches is a sensitive and important nesting area for Little Tern and voids within the rock revetments can attract predatory animals to the area. Therefore, this location will be a concrete upper revetment rather than a full rock revetment. This will have less impact in dissipating wave energy compared to a rock revetment, so a high wave wall might be required in this location.

All existing access points to the beach will be maintained. Due to the proposed revetment taking up a larger footprint of the beach, access to and from the beach could be reduced and therefore during design development the need for additional access points will be reviewed.

The proposals use the following material types: quarried rock (delivered by sea), geotextile and reinforced concrete (in-situ and pre-cast).

The MCA tables in 5.3 provide a detailed commentary on the relative advantages and disadvantages of each of the options against the various core criteria and objectives.

The top **advantages** identified with this option (in comparison to Option B) are as follows:

- Non-complex construction; and
- Minimal maintenance burden and expenditure.

The top **disadvantages** identified with this option (in comparison to Option B) are as follows:

- High risk of impacts on biodiversity & possible/probable requirement for IROPI;
- Long construction period; and
- Significant volumes of material required.

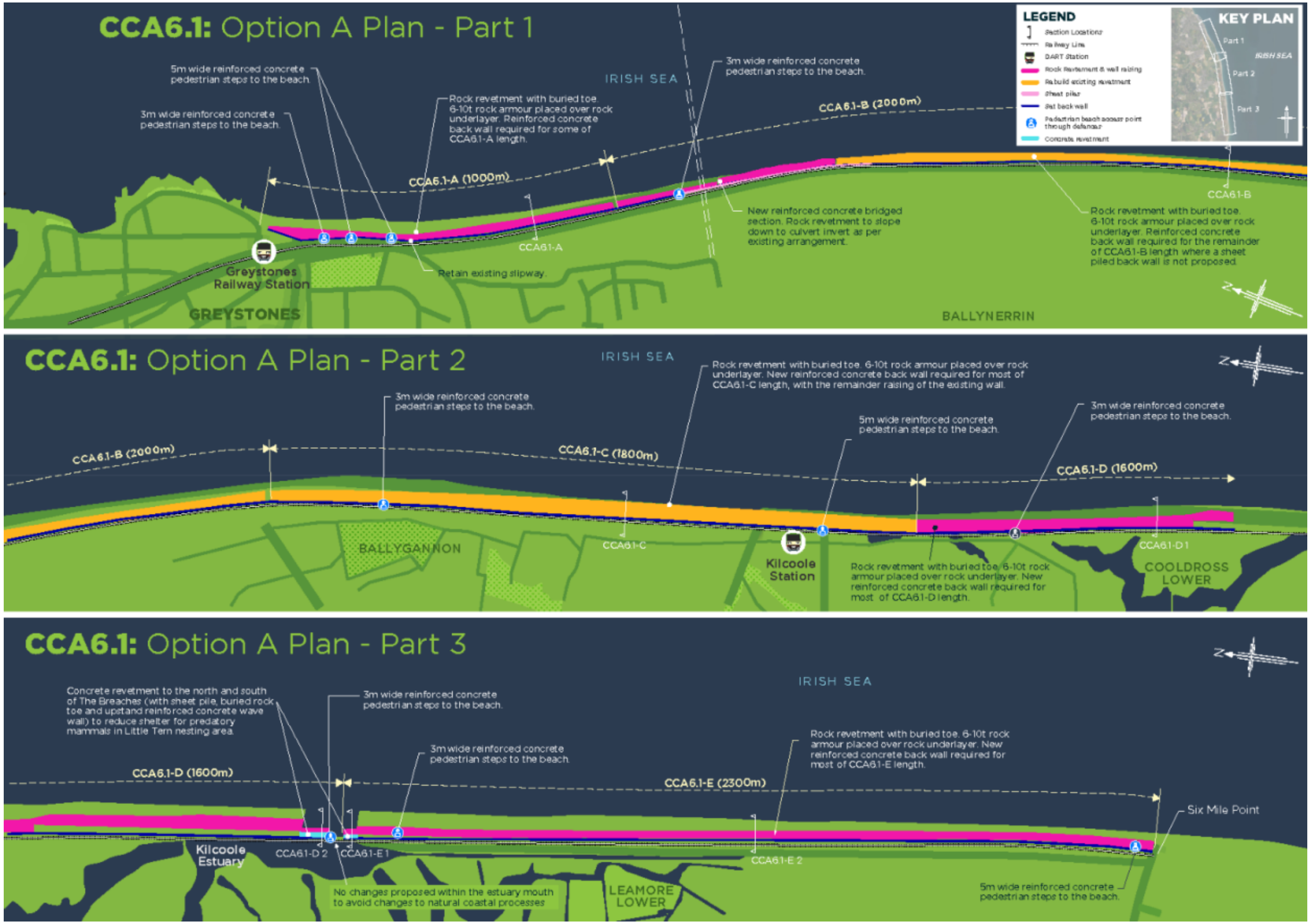

Figure 5-1 CCA6.1 Option A Concept Design Plan

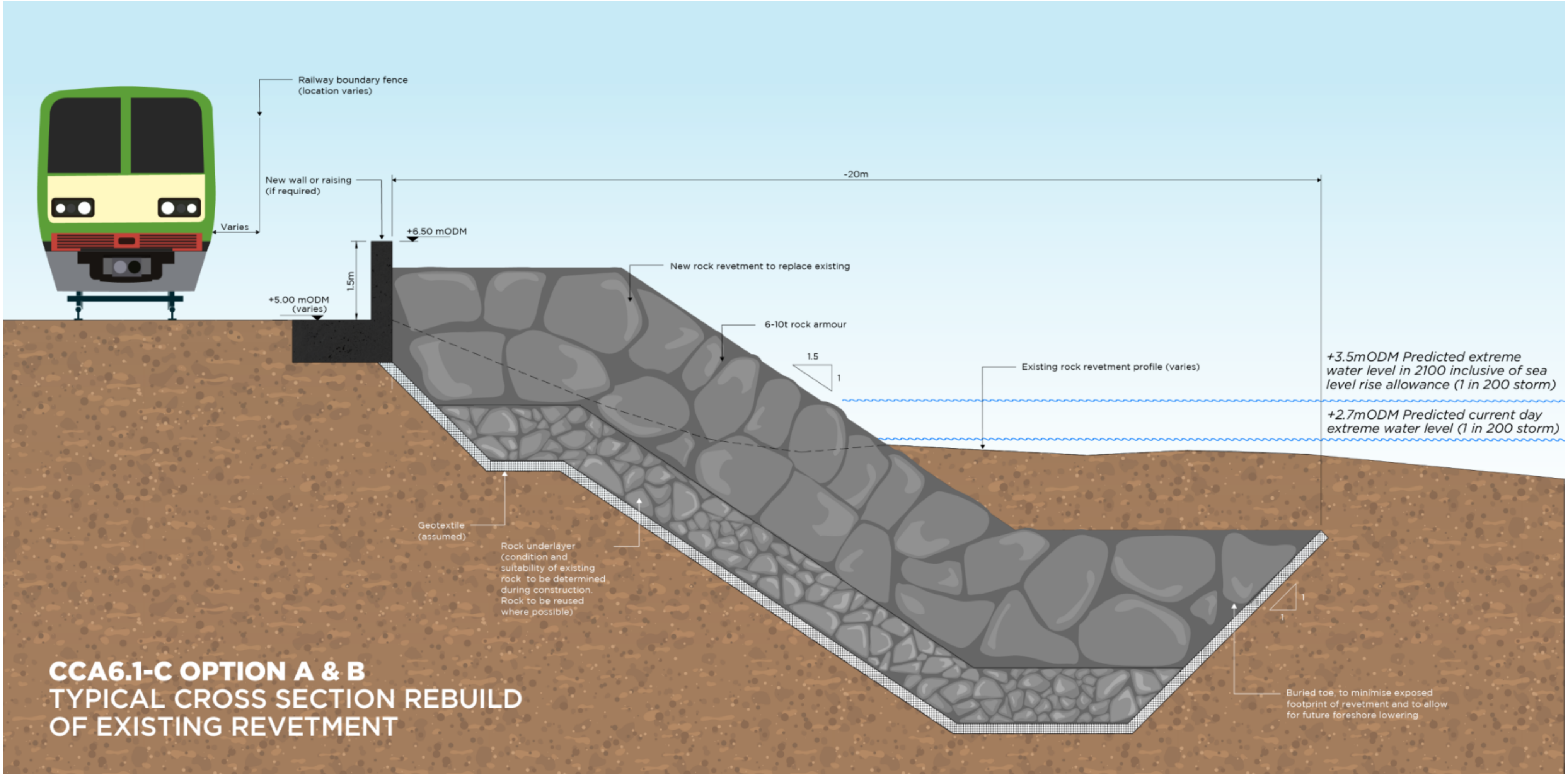

Figure 5-2 CCA6.1-C Option A & B typical cross section

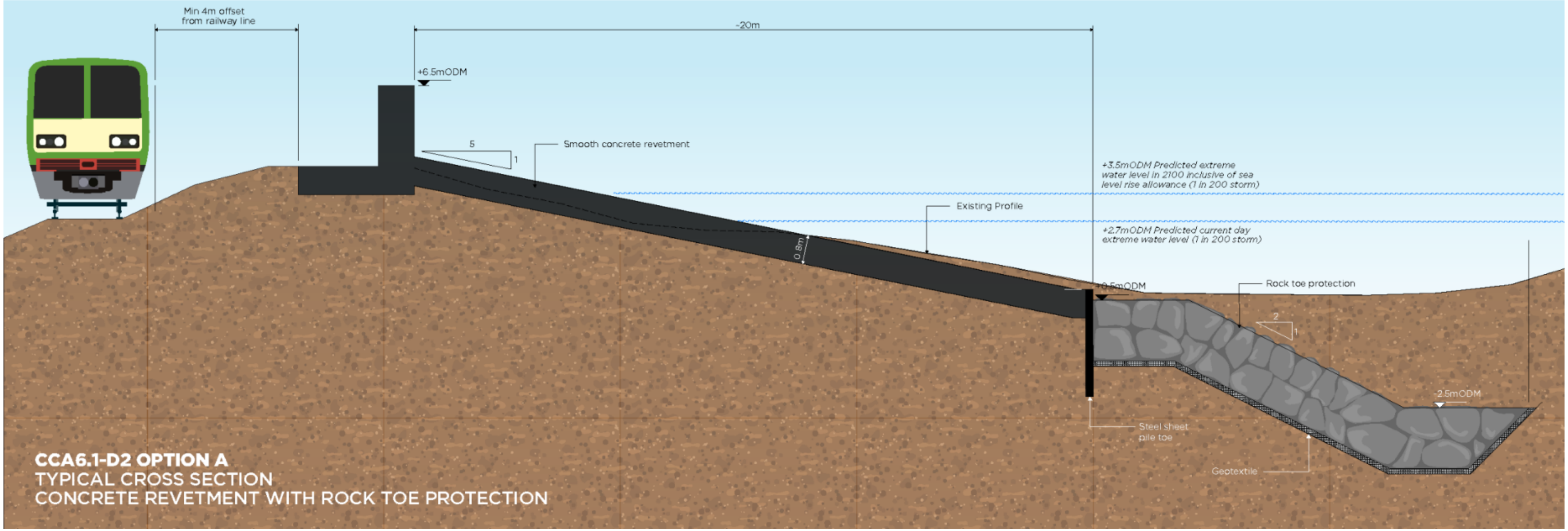

Figure 5-3 CCA6.1-D2 Option A typical cross section

5.4.1.2 Option B

The Concept Design for sub-cells CCA6.1-B, CCA6.1-C and CCA6.1-E is the same as presented for Option A in Section 5.4.1.1.

The Option B concept design proposed for each of the sub-cells is summarised by Figure 5-4 This is further detailed by the concept design engineering drawings in Appendix E.

The variations for Option B are summarised as follows:

- At CCA6.1A no works are proposed until 2055 when localised rock protection will be placed where required to protect the existing structures, along with beach nourishment, if required in the northern section of the sub-cell. To the south of CCA6.1-A it is anticipated that a rock revetment will be required in approximately year 50.
- At CCA6.1-D a rock berm will be placed in front of the existing vegetated beach, combined with a flood wall approximately 4m seaward of the railway line boundary.

This option acknowledges that at CCA6.1-D, the existing beach is relatively healthy (wide)), and the railway line is setback further from the crest of the beach. Installing a rock berm along the seaward edge of the vegetated beach crest will reduce the rate of erosion of the beach and therefore limit the risk to the railway line. However, as future sea levels rise, the railway line will be at risk of flooding. Therefore, a full rock revetment will be required in year 50 (timings to be confirmed during design development) to limit the wave overtopping to the railway line.

No works are proposed in the area just north of The Breaches which is a designated area for Little Terns breeding. This area is also more vegetated and the existing ground levels are higher so the railway line is at less risk in this location.

The proposals use the following material types: quarried rock (delivered by sea), geotextile and reinforced concrete (in-situ and pre-cast)

The MCA tables in 5.3 provide a detailed commentary on the relative advantages and disadvantages of each of the options against the various core criteria and objectives.

The top **advantages** identified with this option (in comparison to Option A) are as follows:

- Lower initial capital cost;
- Lower IROPI risk;
- High potential for adaptation; and
- Shorter initial construction period.

The top **disadvantages** identified with this option (in comparison to Option A) are as follows:

- Higher monitoring and maintenance burden than other options; and
- High likelihood for future capital works, with associated funding risk.

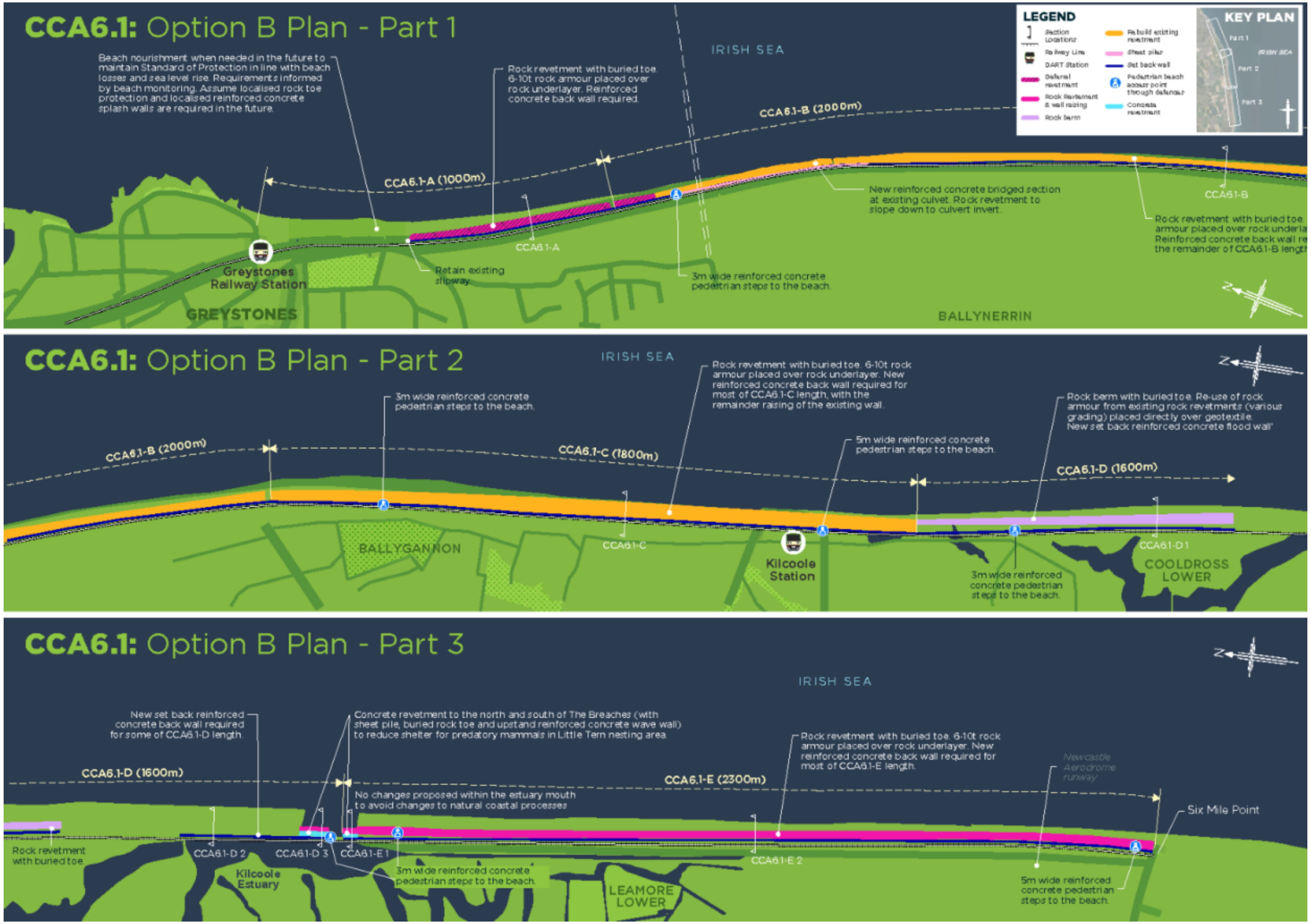

Figure 5-4 CCA6.1 Option B Concept Design Plan

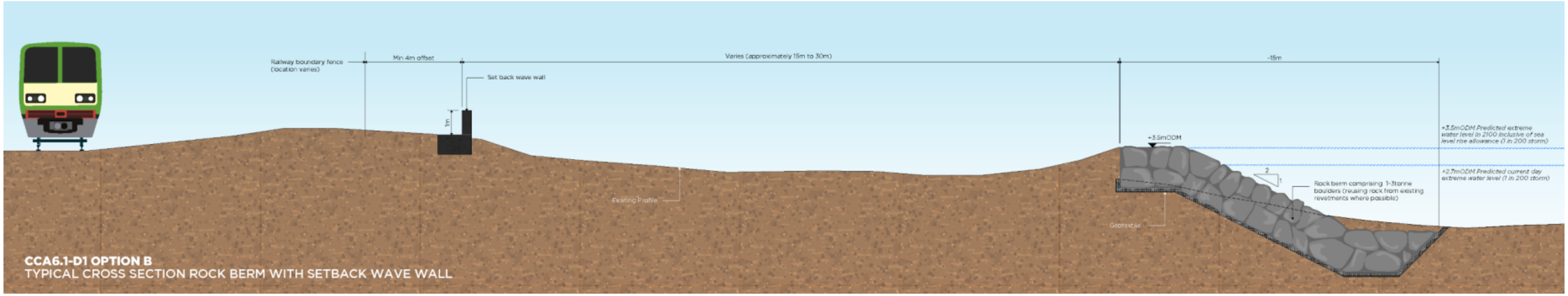

Figure 5-5 CCA6.1-D1 Option B typical cross section

5.4.2 Cost estimates

A high level cost estimate has been prepared for each of the Top-Ranking Short List Options to enable to a comparison between the cost of the options. Option B is the lowest cost option. Option A is 29% more expensive. This is due to Options B requiring less capital works and therefore smaller volumes of rock compared to Option A.

5.5 Emerging Preferred Option

Following the Concept Design, options modelling, options costing and MCA, **the Emerging Preferred Option (EPO) to be taken forward is Option A.**

Table 5-14 Summary of metrics to support the identification of the EPO provides a summary of how Option A (rock revetments and wave walls) was identified as the EPO for CCA6.1. The table below concentrates on the main differentiators between the options.

Table 5-14 Summary of metrics to support the identification of the EPO

Key Metrics	Summary of Outcomes
Meeting objectives	Option A meets the scheme objectives outlined in Section 1.2 (for all sub-cells). Option B meets most objectives, but doesn't provide the full 100-year design life for the sub-cells where a deferred option is presented.
Community	Option A requires larger rock structures over a larger frontage than Option B. Whilst the use of rock revetments is in-keeping with the existing defence measures within the frontage, the extents will more extensive and will further restrict beach access and harden all natural beach areas. Option B initially has smaller, less impactful structures, but eventually all areas will require the large revetments that Option A delivers up-front (as and when climate change impacts are realised) and the long-term community impacts may eventually align.
Technical	Option A is a relatively straightforward option to design using standard coastal protection measures. Option B relies on future beach monitoring to inform when in the future the smaller rock berms will need to be replaced with larger rock revetment structures. The adaptive management approach for Option B has less certainty over the longer term but provides more adaptation options.
Constructability	Both Option A and Option B are relatively straightforward to construct (despite being significant in scale). Option A requires deeper excavations in the beach at the locations where Option B is seeking to defer works, but it only requires one construction phase. Both options may require APIS at Cobblers Bulk where works within the railway footprint are likely to be required due to the space constraints here.
Environmental	Option A has the largest initial footprint onto the designated intertidal areas and will have the longest impact due to the increased construction duration. Option B has reduced impact on the environment in the short/medium term, but in the long term, as the rock berms eventually need to be replaced by larger rock revetments, the overall operational impacts will increase and align with Option A. Due to the need to undertake additional works in the long term, the temporary environmental impact will be increased to cover multiple construction phases.
Sustainability	Option A and Option B both rely on significant rock structures, but the initial rock volumes for Option A are much higher. Option B has the advantage that it defers more significant works until they are needed. Future works within the year 2100 horizon may be avoided entirely in some areas depending on actual sea level rise and how the beach evolves as climate change impacts are realised.
Consenting	Option A scores highly in terms of its potential ability to integrate (landscape) which may help to reduce objection. However, it scores poorly in regard to impacts upon amenity and biodiversity which is likely to attract objection and lead to delay and or greater potential for consent to be refused.

	Option A carries a risk of direct impacts upon Qualifying Interests (QIs) leading to an increased potential for the proposal to have to undergo the IROPI process which again, increases the risk or delay and or refusal of planning permission. Option B scores higher than Option A in terms of its ability to integrate (landscape). It has a similar score in terms of biodiversity and potential for IROPI. However, Option B includes enhancement of the area with beach amenity, coastal recreation amenity and elements of green infrastructure that are all consistent with the objectives of the development plan. Furthermore, Option B has less concrete and hard infrastructure than Option B (in the short/medium term) and generally less potential impacts across the length of coastline.
Cost	The capital cost for Option A is 29% higher than Option B.

5.6 Implementation Options

This stage of the optioneering assessment identifies the capital works scheme to be delivered under the Project (to be delivered alongside required maintenance of existing structures).

The works for the Emerging Preferred Option A within each sub-cell of the CCA were prioritised based on the current vulnerability of the railway to coastal hazards (Section 5.6.1). Implementation Options were developed for the CCA, identifying options for prioritising works to align with increasing coastal hazard and risk to the railway (Section 5.6.2). These options were assessed using MCA (Sections 5.6.3 and 5.6.4) to identify the Emerging Preferred Scheme (EPS) to be delivered under the Project (Section 5.7).

5.6.1 Works prioritisation

The works within each sub-cell have been defined in Table 5-15, with their associated priority and justification for the ranking. Refer to Appendix F Works Priorities Drawing which outlines the extent of the works within the sub-cells.

Table 5-15 Works prioritisation justification (EPO Option A)

Sub-cell (length, m)	Description of works (Priority)	Justification for prioritisation
CCA6.1-A1 (690m)	Rock revetment and floodwall (Priority 4)	There is a wide beach in front of the railway corridor along this section and the beach is predicted to continue to accrete. Therefore there is minimal risk to the railway corridor from wave overtopping or erosion. Works may be required in the long term should the beach be lost as climate change impacts are realised. Manage future risk through coastal monitoring.
CCA6.1-A2 (230)	Rock revetment and floodwall (Priority 3)	The beach here is narrower compared to CCA6.1-A1 and there is less of a buffer back to the railway corridor, but the beach is relatively stable and provides protection to the railway. Monitoring of the beach is recommended here to determine when works may be required.
CCA6.1-B (2,150m)	Rebuild of existing revetment (no priority)	The existing revetments provide protection against shoreline erosion. Ongoing maintenance of the revetments is required and future upgrades are likely to be required to protect the railway corridor against wave overtopping as climate change impacts are realised. This will be undertaken through separate projects outside of ECRIPP.

Sub-cell (length, m)	Description of works (Priority)	Justification for prioritisation
CCA6.1-C (1,650m)	Rebuild of existing revetment (no priority)	As per CCA6.1-B
CCA6.1-D1 (200m)	Rock revetment (Priority 1)	There is only a relatively small buffer between the railway corridor and the shoreline. The railway corridor here is low lying and at risk from wave overtopping in the short term. The shoreline is also vulnerable to erosion during storm putting the railway corridor further at risk. A rock revetment will mitigate the erosion and manage the wave overtopping risk.
CCA6.1-D2 (700m)	Rock revetment (Priority 3) and floodwall (Priority 4)	The beach along this section is relatively stable and there is a large buffer back to the railway corridor. Therefore some erosion of the shoreline from storms is not expected to put the railway corridor at risk. A rock revetment is proposed in the medium term to manage erosion and in the longer term a floodwall may be required to manage overtopping risks as climate change impacts are realised. Monitoring of the beach is recommended here to determine when works may be required
CCA6.1-D3 (450m)	Rock revetment (Priority 4)	The vegetation along this section is higher compared to other locations and there is a larger buffer back to the railway corridor. Therefore there is a low risk to the railway corridor from erosion and wave overtopping. Works may required in the longer term as climate change impacts lead to erosion of the vegetated areas. Monitoring of the beach is recommended here to determine when works may be required.
CCA6.1-D4 (330m)	Set back floodwall (Priority 3)	There is a reasonably large buffer back to the railway corridor here so there is a low risk to the railway corridor from erosion and wave overtopping in the medium term. A set back flood wall is likely to be required in the medium term to manage the risk from wave overtopping as climate change impacts are realised. Monitoring of the beach is recommended here to determine when works may be required.
CCA6.1-D5 (50m)	Concrete revetment with upstand wall and rock toe (Priority 1)	This is in the location of The Breaches where the railway corridor is at risk from wave overtopping in the short term. The beach is also very dynamic at this location resulting in variability in exposure.
CCA6.1-E1 (40m)	Concrete revetment with upstand wall and rock toe (Priority 1)	As per CCA6.1-D5
CCA6.1-E2 (625m)	Rock revetment and floodwall (Priority 1)	The railway corridor is low lying and there is no buffer between the railway corridor and the front of the

Sub-cell (length, m)	Description of works (Priority)	Justification for prioritisation
		vegetation in this location putting the railway corridor at risk from wave overtopping in the short term. A rock revetment will manage the erosion risk whilst a floodwall is likely required to manage the overtopping risk.
CCA6.1-E3 (900m)	Rock revetment (Priority 3) and floodwall (Priority 2)	There is a reasonable buffer to the railway corridor here, however erosion during storms could significantly reduce this, putting the railway corridor at risk from overtopping in the short term. A set back flood wall will manage the overtopping risk in the short term and a rock revetment will likely be required in the medium term to manage the erosion risk. Monitoring of the beach is recommended here to determine when works may be required
CCA6.1-E4 (400m)	Rock revetment and floodwall (Priority 1)	There is a reasonable buffer to the railway corridor here but the beach is predicted to erode, combined with potential erosion from storms puts the railway corridor at risk from overtopping in the short term. A rock revetment with a floodwall will manage the erosion and overtopping risk.
CCA6.1-E5 (275m)	Rock revetment and floodwall (Priority 2)	There is currently some rock protection along this section but it is not sufficient to provide protection to the railway corridor against wave overtopping and erosion. Erosion of the beach is predicted along this section and there is no buffer between the beach and the railway corridor. Therefore a rock revetment with a floodwall is required in the short term to manage the overtopping and erosion risk.

The prioritisation of works for the Emerging Preferred Option A are summarised in Table 5-16.

Table 5-16 Works prioritisation for EPO Option A within CCA sub-cells

Priority	Description of works (sub-cells)	Present day understanding of when works required by
Priority 1	Rock revetments (D1, E2, E4), concrete revetment (D5, E1) and concrete floodwall (E2, E4)	2030
Priority 2	Rock revetment (E5), Concrete floodwall (E3, E5)	2050
Priority 3	Rock revetments (A2, D2, E3) and concrete floodwall (A1, A2, D4)	2050 – 2075
Priority 4	Rock revetments (A1, D3), concrete floodwall (D2)	2075 - 2100

5.6.2 Implementation Options list

The Implementation Options developed for the CCA are provided in Table 5-17. This includes various options for prioritising works to align with increasing coastal hazard and risk to the railway line.

Table 5-17 Implementation Options for EPO Option A

Implementation Option	Works to be delivered under Project [comparative cost of IO in comparison to IO1]	Future capital works needed by 2050	Future capital works needed between 2050 to 2075	Future capital works possibly needed beyond 2075
Implementation Option 1 (IO1)	**Priority 1 to 4** Rock revetments (A1, A2, D1, D2, D3, E2, E3, E4, E5), concrete revetment (D5, E1) and concrete floodwall (A1, A2, D2, D4, E2, E3, E4, E5) [100%]	No works needed	No works needed	No works needed
Implementation Option 2 (IO2)	**Priority 1 to 3** Rock revetments (A2, D1, D2, E2, E3, E4, E5), concrete revetment (D5, E1) and concrete floodwall (A1, A2, D4, E2, E3, E4, E5 [76%]	No works needed	No works needed	**Priority 4** Rock revetments (A1, D3) concrete floodwall (D2)
Implementation Option 3 (IO3)	**Priority 1 and 2** Rock revetments (D1, E2, E4, E5), concrete revetment (D5, E1) and concrete floodwall (E2, E3, E4, E5) [44%]	No works needed	**Priority 3** Rock revetments (A2, D2, E3) and concrete floodwall (A1, A2, D4)	**Priority 4** Rock revetments (A1, D3) concrete floodwall (D2)
Implementation Option 4 (IO4)	**Priority 1** Rock revetments (D1, E2, E4), concrete revetment (D5, E1) and concrete floodwall (E2, E4 [33%]	**Priority 2** Rock revetments (E5) and concrete floodwall (E3, E5)	**Priority 3** Rock revetments (A2, D2, E3) and concrete floodwall (A1, A2, D4)	**Priority 4** Rock revetments (A1, D3) concrete floodwall (D2)
Implementation Option 5 (IO5)	Reactive Maintenance (Do Minimum) [N/A]	Reactive Maintenance	Reactive Maintenance	Reactive Maintenance

5.6.3 MCA Outcomes

A multi-criteria analysis was undertaken having regard to the TAF criteria to identify the Emerging Preferred Scheme.

This section summarises the outcome from the Implementation Option (IO) MCA analysis. The full MCA sheet can be found within Appendix G. Table 5-18 below provides an outline of the results of the analysis for all of the relevant criteria.

5.6.3.1 Economy

Both IO1 & IO2 score similar in relation to economy. Both options require significant capital investment due to the significant volume of rock and construction required. Both IO's would also require a routine and post-storm monitoring plan with minimal maintenance throughout their design life which scores favourably.

IO3 proposes fewer works than IO's 1 and 2 prior to 2050 so requires less significant capital investment. Similar to IO's 1 and 2, IO3 will require a routine and post storm monitoring plan and should require minimal maintenance up to 2050, however, additional monitoring and maintenance may be required in areas where works are deferred.

IO4 requires less significant capital investment in the short term in comparison to the other IO's. However, further investment would be required by 2050, which would increase the overall cost of the works due to economies of scale. IO4 would also require additional monitoring and maintenance in areas where works have been deferred.

IO5/ Do Minimum will rely on reactive maintenance and so requires minimal capital investment in the short term. While the short term capital investment would not be as significant as the other IO's, there is little cost certainty due to the nature of undertaking extensive and frequent reactive repairs.

5.6.3.2 Safety

Both IO1 & IO2 propose significant amounts of rock revetment, concrete revetment and concrete floodwalls throughout CCA6.1. The amount of construction works proposed in comparison to other IO's increases the construction health and safety risk significantly. Although rock armour would be delivered by sea, construction works will take place exclusively on land which reduces the risk. During the operational phase, there is the potential that members of the public could climb on the revetments, to discourage this warning signs will be displayed. The revetments will also significantly reduce the usable area of the beach which could lead to members of the public being trapped by the tides. To mitigate this, increased access points will be incorporated into the revetments. Operational maintenance for both IO's should be minimal.

IO3 requires less construction than IO1 & IO2 which reduces the construction risk significantly. The same operational risks apply with regards to the rock revetments however due to the significant reduction in volume of the proposed revetments this risk can be reduced.

IO4 requires significantly less works in comparison to IO's 1-3, however, there is a higher potential need for emergency repair work. This IO could result in continued erosion and a higher potential need for local remedial works in areas where the works are deferred, increasing the construction and operational health and safety risk.

IO5/Do Minimum proposes no construction works. However, there would be a requirement for localised remedial works. Due to immediate risks to the rail line, these could be undertaken under poorer working conditions. In the operational phase, a lack of proactive monitoring and maintenance could lead to deterioration of existing defences. This alongside continued coastal erosion will significantly negatively impact operation of the rail line.

5.6.3.3 Accessibility & Social Inclusion

IO1 proposes rock revetments, concrete revetments and concrete floodwalls throughout CCA6.1 which has the potential to negatively impact access and the public's ability to use the beach for social and recreational purposes.

IO2 proposes similar works to IO1 with the exception of rock revetments at subcells A1, D3 and a concrete floodwall in subcell D2. Impacts are similar to IO1, however the use of the beach at subcells A1 & D3 will not be affected so this scores slightly better.

IO3 proposes less works in comparison to IO1 & IO2. IO3 scores better than IO1 & IO2 due to the minimisation of impacts to beach amenity at Greystones North Beach and Kilcoole Estuary. However, further works would be required post 2050.

IO4 proposes significantly less works in comparison to IO's1-3. However, the lower level of protection that this IO provides has the potential to have an impact on the amenity use of the beaches where the works will be deferred. This has the potential to reduce the amenity value for the public.

IO5 (Do Minimum) provides significantly less protection than IO's1-4 and therefore it has significant disadvantages in terms of accessibility and social inclusion due to potential risks associated with climate change and damage and/or collapse of existing defences. As coastal erosion continues over time, access to the beach will be somewhat curtailed.

5.6.3.4 Integration

All IO's with the exception of IO5/Do Minimum are aligned to development, climate and transport plans. However, IO1-4 do not fully meet Wicklow County Council's Marine Cells 4, 5 and 6 because they impact natural habitats, European Sites and protected views and prospects and do not provide coastal recreation amenities or incorporate pedestrian/cycling infrastructure. IO's 1 and 2 have some disadvantages due to the significant volumes of material necessary for construction and a reduction in the amenity area of the beach within CCA6.1. IO4 avoids the significant volume of materials required and transport of the same until after 2050, however, it does not provide coastal protection as robust as IO1, 2 and 3. IO3 has advantages over other options as it provides robust coastal protection in line with development objectives, while also requiring less significant volumes of material than IO's 1 and 2. IO5/Do Minimum does not address long term climate issues and build long-term resilience of the rail line against coastal erosion and flooding, therefore, this IO is not aligned to development, climate and transport plans.

5.6.3.5 Environment

IO's 1 and 2 require extensive construction works and as such have the potential for very significant environmental impacts including, noise and vibration, air quality and waste generation. They also have a significant negative carbon impact in the short-term due to the very significant volume of materials required. However, in the long term these IO's will have a positive carbon impact as they will facilitate operational phase reliance on public transport and so reduce reliance on private vehicles.

IO's 3 and 4 propose significantly less works than IO's 1 and 2 so are significantly less impactful on the environment during the construction phase. The majority of noise sensitive receptors in CCA6.1 are located within subcells A and B and works in A1 and A2 are deferred for IO's 3 and 4 and so noise impact is significantly reduced in comparison to IO's 1 and 2. IO3 keeps the volume of materials required to a minimum whilst affording robust protection to the railway and so the carbon impact is less significant than that of IO's 1 and 2. IO4 keeps the volume of materials to an absolute minimum, however, provides a lower level of protection to the rail line than IO's 1, 2 and 3 and will require further works to maintain the level of protection.

IO5/Do Minimum requires significantly less works than other IO's and so is less impactful on the environment during the construction phase. However, continued reactive interventions will cause longer term impacts to noise and vibration and air quality impacts. This IO will lead to increased impacts to operation of the rail line.

Marine delivery of rock armour means there is a small risk of impact on archaeological features in the intertidal and marine elements. This risk is most significant for IO1 due to the large volume of materials required. IO1 has the potential for indirect setting and visual impacts on four NIAH sites (16304027; House, 16304058; Railway Station, 16304095; Library/Archive and 16401912; Station master's house) three of which are also RPS Sites (16304058; RPS ref 08-63, 16304095; RPS ref 08-24 and 16401912; RPS ref 13-38) and one further RPS site (19-12; Five Mile Point). IO2 also has potential for indirect setting and visual impacts on these five sites, however, NIAH sites 16304027, 16304058 and 16304095 are all within proximity to sub cell area A1 and for this IO the concrete flood wall will be constructed in this location, but rock revetment works are deferred. Due to deferral of works, IO3 only has potential for indirect setting and visual impacts on NIAH site 16401912 and IO4 does not have potential for indirect setting and visual impacts on any of the five identified sites.

Potential impacts to soils and geology, landscape and biodiversity reduce as the extent of the works decreases, therefore, IO's with higher deferral of works have less significant impacts. With the exception of IO5/ Do Minimum as although this IO does not propose construction works, continued degradation of the coastline and reactive interventions will lead to significant impacts to soils and geology, landscape and archeology, architectural and cultural heritage. There is one SAC (The Murrough SAC), one SPA (The Murrough SPA) and one pNHA (The Murrough HNA) within CCA6.1. Biodiversity will be impacted due to construction effects including disturbance to QI species and habitat degradation and loss of QI species under the footprint of the revetment. All IO's will negatively impact biodiversity to some extent, however, deferral of works for IO2, 3 and 4 will reduce the potential for impacts on European sites and their qualifying interests.

5.6.3.6 Engineering

Both IO1 and IO2 propose extensive works which will require a significant volume of rock armour, this will result in construction being slow. Due to the marine delivery of materials and extensive rock revetment proposed the constructability of these options is challenging. During construction there will be minimal impact on rail services and Irish Rail will be notified of all works as they will be taking place adjacent to the rail line. Both options would require a routine and post storm monitoring plan and should require minimal maintenance during the design life, IO2 may require additional maintenance in areas where works are deferred. These options have limited adaptability as changes to rock revetments would be complex and somewhat limited. The use of resilient hard engineering techniques means that IO1 and IO2 have low residual risk.

IO's 3 and 4 require significantly less rock armour than IO's 1 and 2 which simplifies the constructability of these options. Similar to IO's 1 and 2, railway operation will not be impacted by the construction phase of these IO's. However, these IO's could require additional maintenance in areas where the works are deferred. IO4 defers a greater extent of works than IO3 so the deferral impacts discussed above will be more significant for IO4 than IO3. Future adaptation is accounted for in the design of these IO's. IO4 has residual risk because deferral of the works would lead to continued coastal erosion in areas that are left unprotected.

IO5/Do Minimum would rely on emergency works to the existing wall adjacent to the railway and localised emergency works due to significant weather events. These reactive works are likely to impact rail operations as they will not be planned and there will be no strategy in place. This IO relies heavily on monitoring and maintenance and there are minimal opportunities for adaptation. There is also an increased risk of rapid failure of the existing hard defences within CCA6.1.

5.6.3.7 Planning Risk

All IO's with the exception of IO5/Do Minimum will require works within European sites. While IO1 & IO2 propose significantly more works, there is still potential for IROPI on all options. While IO4 proposes the least amount of works, there will likely be a requirement for future consents to be obtained by 2050 for further works.

5.6.4 Summary

A summary of the MCA outcomes are shown in Table 5-18. Implementation Option 3 has been identified as the Emerging Preferred Scheme to be taken forward. The basis for this is summarised as follows:

- Option 3 is the top ranked option under Safety, Accessibility & Social Inclusion and Integration.
- Option 3 is also joint top ranked for Environment and Climate.

Table 5-18 Implementation Options MCA outcomes summary

	IO1	IO2	IO3	IO4	IO5/Do minimum
Economy					
Safety					
Accessibility & Social Inclusion					
Integration					
Environmental					
Engineering					
Planning					

5.7 Emerging Preferred Scheme

The **MCA has identified the Emerging Preferred Scheme (EPS) as Implementation Option 3 (IO3) for EPO Option A**. The Emerging Preferred Scheme (EPS) will deliver a minimum of 50 years (2075) protection to the railway line against coastal erosion hazards at locations where the railway line would be at risk in the next 25 years (2050) if no capital works were undertaken. The capital works delivered under this Project will form part of the longer term works likely needed to protect the railway line to 2100.

The works identified under the EPS comprise:

- Rock revetments in parts of Cooldross (CCA6.1-D) and Newcastle North (CCA6.1-E).
- Concrete revetments in small sections of Cooldross (CCA6.1-D) and Newcastle North (CCA6.1-E) around The Breaches.
- Reinforced concrete floodwalls through much of Newcastle North (CCA6.1-E).

These works are summarised by Figure 5-6, Figure 5-7 and Figure 5-8

Further detail regarding the components of the EPS is detailed in Section 7.

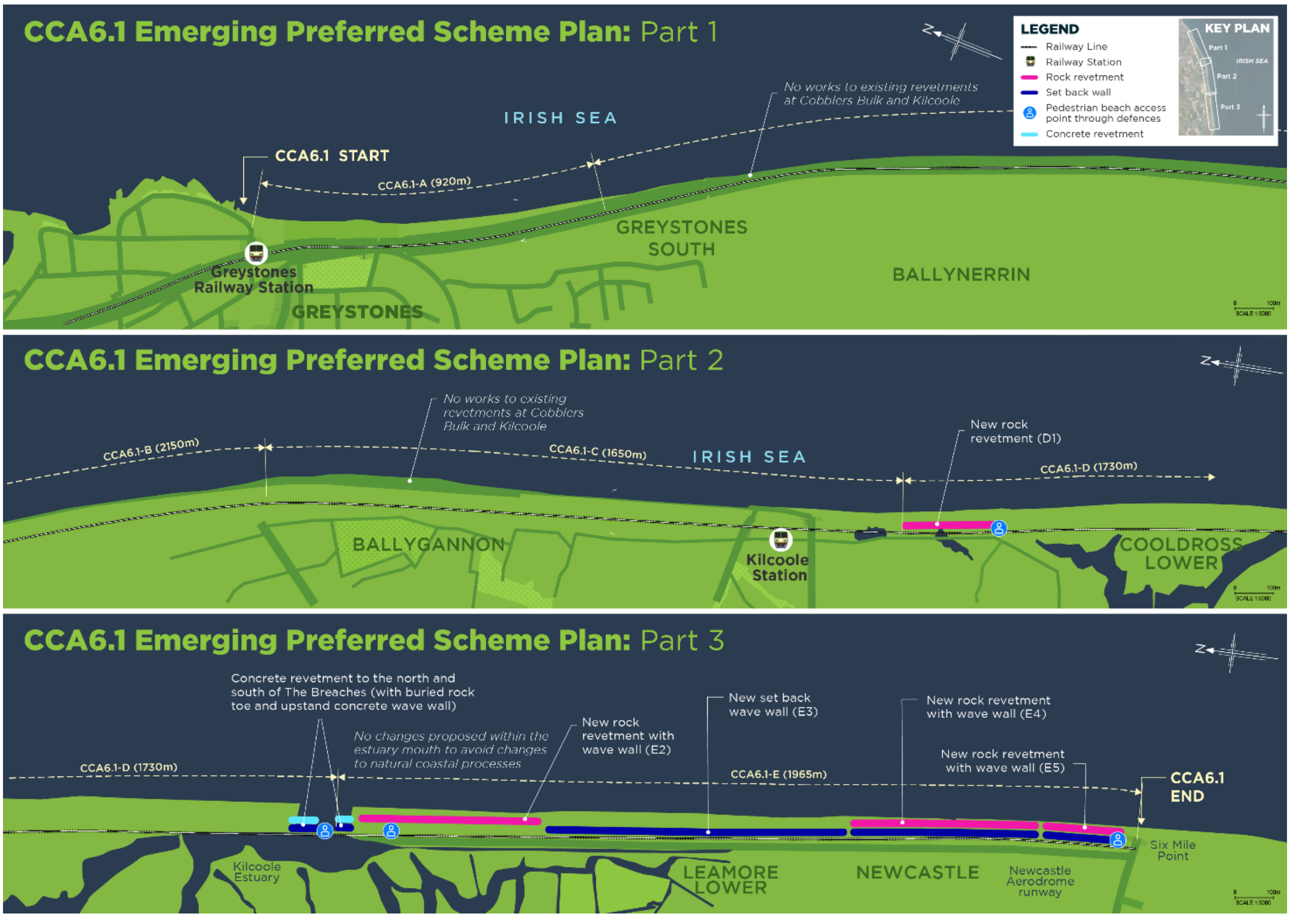

Figure 5-6 CCA6.1 Emerging Preferred Scheme Plan

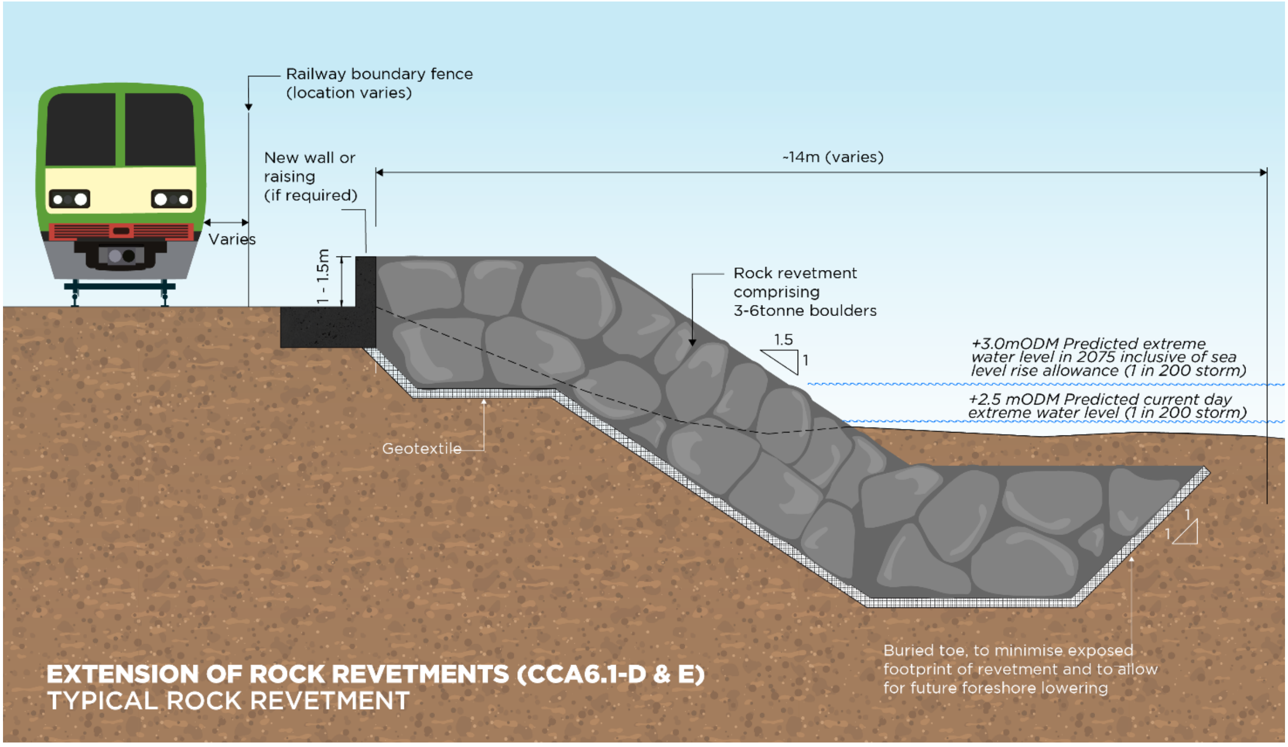

Figure 5-7 CCA6.1 Emerging Preferred Scheme typical section

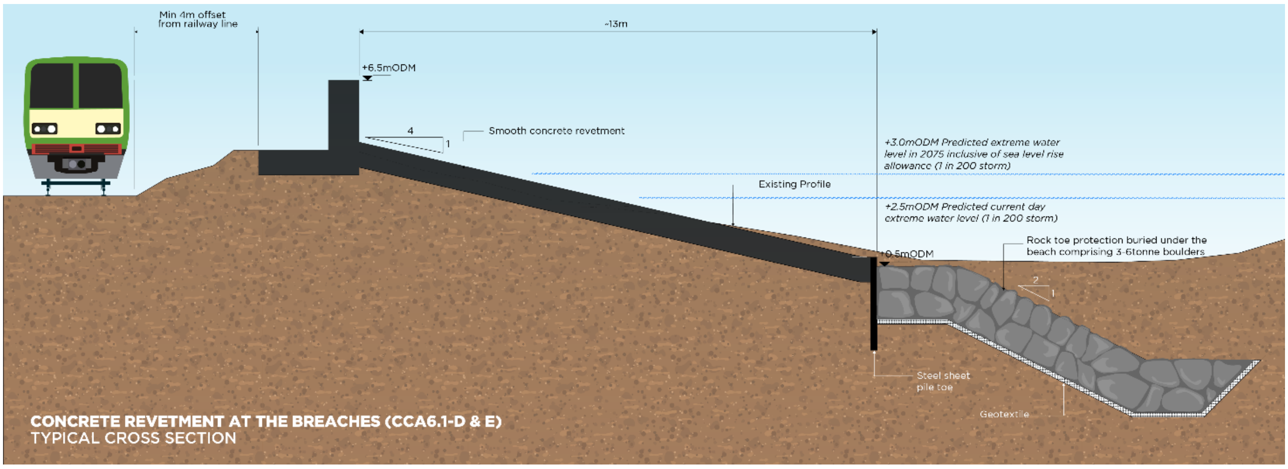

Figure 5-8 CCA6.1 Emerging Preferred Scheme typical section at The Breaches

6. Stakeholder and Public Consultation

This section is draft for public consultation. This section will be updated following the public consultation to summarise the key outputs of this consultation process.

To ensure consultation and engagement is carried out in a transparent and meaningful way, and that the views of all stakeholders are considered in the development of the Project, the consultation process will be compliant with all applicable legislative, planning and best practise requirements.

The Project will consult with members of the public, statutory stakeholders and all interested stakeholders subject to review and where applicable, consideration has been given to ensure compliance with the following:

- The Aarhus Convention - Public Participation Directive 2003/35/EC;
- Freedom of Information Act 2014;
- Planning and Development Acts 2000 – 2018;
- Access to Information on the Environment (AIE) Regulations;
- The General Data Protection Regulation 2016;
- Regulation of Lobbying Act 2015;
- Transport (Railway Infrastructure) Act 2001, as amended;
- European SEA Directive 2001/42/EC;
- European Habitats Directive 92/43/EEC; and
- European EIA Directive 2014/52/EU.

6.1 Non-Statutory Public Consultation

Public consultation on the Emerging Preferred Scheme is on a non-statutory basis and is a key element in ensuring that stakeholders, landowners and the public can contribute to the development of the design. Consultation with the public will ensure the Project is capturing and addressing specific local concerns.

Public consultation is running for four weeks to seek feedback on the Emerging Preferred Scheme. The project is facilitating an in-person event open to the public and all stakeholders with members of the project team in attendance to provide guidance to those making submissions. This event is taking place in a venue near the coastal cell area to facilitate local residents, business and landowners. Key design concepts will be presented and visually displayed with opportunities to give feedback directly to the project team.

All consultation information will be available online and to download on the Project website. Members of the public can submit feedback via email, post, a survey/questionnaire and via phone.

6.2 Key stakeholder consultation

Pre consultation briefings with technical stakeholders has taken place throughout the option selection process. This includes but not limited to National Parks and Wildlife Services (NPWS), Birdwatch Ireland, Office of Public Works and Local Authorities. This engagement has helped build and foster open, supportive relationships between the project and technical stakeholders.

Further briefings will be offered to key stakeholders to support the consultation process on the Emerging Preferred Scheme including key environmental organisations, statutory bodies, elected representatives, business representative organisations, landowners, key opinion informers and local residents' groups.

7. Emerging Preferred Scheme

This section is draft for public consultation. It outlines the Emerging Preferred Scheme identified in Section 5. This section will be amended and updated following the public consultation and the 'Emerging Preferred Scheme' will be renamed 'Preferred Scheme'.

7.1 Emerging Preferred Scheme

The Emerging Preferred Scheme (EPS) to be taken forward comprises rock revetments in parts of Cooldross (CCA6.1-D) and Newcastle North (CCA6.1-E), with concrete revetments in small sections around The Breaches. Reinforced concrete floodwalls are needed through much of Newcastle North (CCA6.1-E). These works will vary in form along the frontage relative to the wave exposure, foreshore type/level and to integrate with the various natural and man-made shoreline features.

Further detail regarding the components of the EPS is detailed below. In all cases, a minimum 50-year design life is provided.

7.1.1 Rock Revetment

A rock revetment will be constructed for some frontages to prevent erosion and reduce overtopping onto the railway corridor.

The rock revetment will comprise two layers of graded armour rock overlaying an underlayer on geotextile. The rock grading has been selected to provide stability over the scheme life using modelled wave conditions that allow for sea level rise. The rock grading size will be confirmed during preliminary design but is expected to be in the range of 3-6 tonnes for the majority of the revetments. This rock will be of high quality to ensure that it meets and exceeds the design life.

The geometry of the rock revetments is determined through design calculations to limit the wave overtopping to acceptable thresholds to prevent disruption to the railway line. This is a combination of the slope of the revetment, the height and width of the revetment and the height of the rear wall.

7.1.2 Beach Access Steps

All existing beach access steps will be maintained or rebuilt through the new revetments. These will be concrete steps with handrailing to provide safe access to and from the beach.

7.1.3 Concrete Revetment

In the location around The Breaches a concrete revetment is proposed rather than a rock revetment. The concrete revetement will comprise a concrete slope with a sheet pile at the toe and rock toe protection. The concrete revetment is impermeable and therefore can lead to increased scour potential at the toe of the revetment which could result in undermining of the revetment. Therefore, a sheet pile and rock toe protection will be provided at the base of the revetment. The length of the sheet pile (and need for) and the size of the rock toe protection will be determined during preliminary design following ground investigation works and additional assessments into scour depth and predicted long term foreshore levels. A concrete revetment does not dissipate wave energy in the same way as a rock revetment due to it being impermeable. Therefore, the wave run-up and overtopping will be larger than for an equivalent rock revetment so the wave wall will likely be bigger than required for the rock revetment. The exact geometry of the revetment and wave wall will be determined through wave overtopping and wave loading calculations during preliminary design.

7.1.4 Wave Walls

Many of the rock revetments require a wave wall at the rear of the crest to provide an impermeable barrier at the back of the permeable rock revetments. At concept design stage, it has been assumed that these will be precast reinforced concrete. The size of the walls will be determined through overtopping and wave loading calculations during preliminary design.

7.1.5 Interfaces

The following interfaces will be developed during design development:

- The Breaches – details around The Breaches will be developed to avoid impacting the flow through the estuary mouth
- Services and utilities – All existing services will be identified during preliminary and detailed design and suitable details developed to avoid impact on these services.
- Footpath – Designs will seek to minimise impacts on the coastal footpath.

7.2 Concept Scheme Constructability

This section provides a preliminary outline of key delivery areas.

7.2.1 Construction Methodology

The following methodology is an example of how these structures may be constructed. The appointed contractor may choose to construct the structures in a different way.

It has been assumed that the rock armour material will be procured from overseas and imported by rock barge. It would be favourable to avoid bringing the rock on shore via Dublin Harbour as this adds a significant cost to the handling of the material. Assuming the rock can entirely be handled by marine plant, the rock could be discharged into marine stockpiles as close to the shoreline as possible. Due to the shallow water depths close to the shoreline there may be a requirement to construct a short temporary causeway to enable land-based equipment to retrieve the rock and take it to the work front and its final position. The use of long reach excavators and articulated dump trucks would facilitate this operation. The rock would be transported to the placing equipment. Taking the largest grading of 3-6t rock a large sized excavator would be needed to reach the toe of the revetment.

Rock barge deliveries would need to be constant to ensure material is available for the installation. Depending on how many work fronts are opened up, this will dictate the frequency of rock deliveries from the supplier. Any marine plant engaged on the project would require using Wicklow Harbour for bunkering, crew change, shelter in poor weather etc. so an allowance has been made for these costs.

All revetment options include a buried toe which will need to be excavated prior to placing the rock. Assuming the toe is formed by land-based equipment the revetment would then be built from the toe upwards by placing rock with a large excavator. Once the toe was profiled a geotextile layer would be laid, which the rock armour is then placed upon.

The rocks would be placed individually and built up in layers as per the design. An allowance has been made for temporary protection of the works due to inclement weather which poses a risk to the partially constructed elements. This may be low risk but should be considered as it has a cost associated with it.

As the rock armour is acting as primary armour, placing the rocks to specification is extremely important and this may result in slow progress, especially if areas need to be revisited to bring them into specification. Notwithstanding this, a specialist marine sub-contractor should be able to place rock armour based on the cross section shown in the concept design at around 5-10m per day.

Lengths of new concrete retaining wall will be required for much of the revetment lengths. These walls could be precast and dropped in from the railway using a small all terrain crane or similar. The use of the railway for material import could be feasible. This section of railway only has a few trains per day so overnight possessions should be possible.

The use of precast would remove the need to transport wet concrete to the work areas which would be significantly challenging in some areas. This also provides health and safety benefits.

The wall installation would need to be completed before the rock armour is placed at the crest of the revetment. Excavation to formation level could be undertaken from the seaward side of the railway without the need to close the line. Where the excavation is particularly close to the railway an overnight possession may be needed to excavate and place the wall and backfill to ensure the railway is not undermined by the excavation or the line loaded by passing trains during excavation.

Further works would be required to grout up the joints between the precast units however this could be done during daytime hours in between possessions.

7.2.1.1 Staging areas and compounds

The works would need to be split into work fronts to enable a reasonable duration to be achieved. The number of work fronts opened will be a contractor consideration but for the revetment length in the CCA-6.1, two or three work fronts may be reasonable. It is expected that the construction phase would be managed from one main site compound with smaller satellite compounds along the length of the works providing smaller welfare facilities. The use of the railway may be considered for material offloading due to the proximity to the location of the new concrete seawalls. The use of precast units for the seawall sections may be feasible. The location of the main site compound will be considered once the Preferred Scheme is known.

7.2.2 Construction risks

In the context of construction there will be many project delivery risks. The most significant risk will be related to the works being undertaken in a marine environment, which limits working windows in accordance with tides and working in a dynamic environment. Rock delivery is anticipated to be via marine routes and therefore will be subject to weather risk. This risk may delay works as marine vessels can only operate below certain wave or swell height conditions.

Access to the foreshore is a key challenge as the number of railway crossings are limited. This may result in more construction vehicle movements on the public road network to reach appropriate crossing points.

Working adjacent to the railway line is a key risk as some of the works may need to be carried out under a railway possession. Railway possessions are typically done during night-time hours to limit the impact on the rail network. Restricting works to night working only on the railway presents risk to the programme for delivery for the scheme.

Critical health and safety related construction risks are summarised below:

- Unstable ground conditions - Potential for site operatives or plant to become stuck in pockets of soft or lose ground. Instability of plant working in area of low soil strength.
- Existing services - Damage to existing services during construction leading to death or injury to site personnel.
- Delivery of rock – risk of barge being grounded.
- Handling and placement of rock armour - loss of control of rocks (movement due to soft ground conditions/dropped by construction plant).
- Lifting Operations - Risk of plant overturning during moving or lifting on slope.
- Transportation of precast units - Striking of live services overhead rail cables damaging cables and causing train cancellations and delays.

7.2.2.1 Mitigations

Notwithstanding the abovementioned project delivery risks, these can be mitigated to reduce the impact on the delivery programme. The marine works can be planned to be undertaken during the summer months to reduce the exposure to the poorer weather during the winter months. Appropriate routes for construction traffic can be identified on the existing road network to minimise impact to other road users. Works near the railway can be identified early and discussions with Irish Rail can happen early to ensure the works can proceed as smoothly as possible.

7.3 Health and Safety

Health and safety have been a key factor in the design and option selection process. Health and safety risks, both during construction and following completion of the Project are considered at every stage of the Project, from long list screening through to construction. Risks are eliminated and mitigated where possible, but where a risk cannot be mitigated through design measure, the residual risk is documented and appropriate measures for managing the risk are documented. Health and Safety during the construction phase will be managed by the client and contractor.

8. Conclusions and Next Steps

This section is draft for public consultation. It outlines the conclusions from this Preliminary Options Selection Report. This section will be amended and updated following the public consultation and the 'Emerging Preferred Scheme' will be renamed 'Preferred Scheme'.

8.1 Options Assessment Conclusions

This report has presented the full range of technical solutions to protect the railway from coastal flooding and erosion and has provided evidence for arriving at the Emerging Preferred Scheme comprising rock revetments along some of the frontage with the exception of The Breaches where a concrete revetment will be installed.

8.2 Next Steps

This report identifying the Emerging Preferred Scheme is a key deliverable of Phase 2. The future Project phases to develop and deliver the Emerging Preferred Scheme are summarised below:

- Phase 1 – Project Scope and Approval (completed);
- **Phase 2 – Concept, Feasibility and Options (current phase);**
- Phase 3 – Preliminary Design (next phase);
- Phase 4 – Statutory Process (future phase);
- Phase 5a- Detailed Design and Tender Issue (future phase);
- Phase 5b - Contract Award (future phase);
- Phase 6 – Construction; and,
- Phase 7 – Close out.

8.2.1 Design Development

The next phase of design is Preliminary Design of the Emerging Preferred Scheme (Phase 3). This will develop the Phase 2 Concept Designs to provide increased certainty on the structure geometry and detailing. This stage of design will consider in more detail the interfaces through the development of a 3D design. Further work will be undertaken to consider how the works will be constructed and how construction impacts can be avoided or mitigated. Comments and feedback from PC1 will be considered as part of the preliminary design works.

8.2.2 Opportunities for consultation and engagement

PC1 provides the public the opportunity to provide commentary on the Emerging Preferred Scheme. Once this information has been reviewed and considered, the Preferred Scheme will be selected to progress to preliminary design. At Public Consultation 2 (PC2), stakeholders will be given another non-statutory consultation opportunity to provide commentary on the Preferred Scheme, which will be documented and considered in the completion of the preliminary design. This will enable the Project to progress to Reference Design that will support the development of the Environmental Impact Assessment (documented in an Environmental Impact Assessment Report). This will support the statutory planning process for the Project. Stakeholders will be afforded the opportunity to engage on the Project again at this point. This consultation will be taken into consideration by the approving authority.

8.2.3 Consenting

The only consenting aspects related to the next stage (Phase 3) are the consents for any remaining site surveys that were not progressed during Phase 2. This is currently limited to further ground investigations and a bathymetric survey. There will be ongoing consultation during Phase 3.

The significant consultation tasks will be delivered under Phase 4 comprising the Environmental Impact Assessment (EIA), Appropriate Assessment, Planning Consent application, Foreshore Consent application and supporting public consultation.

On receipt of permission to undertake surveys by MARA, a subsequent application/s will be made to MARA for the Marine Area Consent (MAC). On receipt of a MAC there are a number of potential consenting 'routes' for the subsequent development applications including:

1) Railway Order under the Transport (Railway Infrastructure) Act, 2001 (as amended and substituted);

2) Seventh Schedule Strategic Infrastructure Development (SID) under the Planning and Development (Strategic Infrastructure) Act 2006 and Planning and Development Act, 2000 (as amended);

3) Section 179 'Local Authority Own Development' under the Planning and Development Act, 2000 (as amended) and Part 8 under the Planning and Development Regulations 2001 (as amended); and

4) 'Local' Planning Application under the Planning and Development Act, 2000 (as amended) and the Planning and Development Regulations 2001 (as amended).

All of the above consenting 'routes' are currently under consideration.

8.2.4 Procurement

The construction procurement will commence following the granting of the consents in Phase 5.

8.2.5 Programme

A high-level indicative programme of the next phases is as follows:

- Phase 2 completion programmed following Public Consultation 1 in Autumn 2024;
- Phase 3 programmed for summer 2024;
- Phase 3 completion autumn 2024; and
- Phase 4 programmed for winter 2024 and throughout 2025.

The programme for phases after planning submission (Phase 5 onwards) is subject to application durations.

9. Glossary

Term	Description
Annual exceedance probability	The probability that a given event will be equalled or exceeded in any one year
Antecedent rainfall	Cumulative rainfall totals over a given period
Beach lowering	Reduction in beach surface elevation over a timescale due to cross-shore and longshore sediment transport.
Beach nourishment	Supplementing the existing beach periodically with suitable material to increase beach volumes, reduce erosion and toe scour at flood defences and/or soft cliffs.
Breakwater	Offshore structure which dissipates wave energy due to their size, roughness and presence of voids. This reduces the wave heights at the shoreline defences
Caisson	A watertight retaining structure used as a foundation
Capital expenditure	Funds used to acquire, upgrade and maintain physical assets (e.g., construction costs)
Capping beam	Steel structures that join pile foundations together to increase their rigidity and reduce movement
Carbon management	An approach to mitigate or reduce carbon (or other greenhouse gas) emissions
Catch fence	A fence designed to catch falling debris and absorb impact
Circular economy	A system which reduces material use, redesigns materials, products, and services to be less resource intensive, and recaptures "waste" as a resource
Cliff recession	Landward retreat of the cliff profile (from cliff toe to cliff top) in response to cliff instability and erosion processes
Climate adaption plan	A plan which sets out measures that protect a community or ecosystem from the effects of climate change, while also building long-term resilience to evolving environmental conditions
Climate change	A change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide
Climate resilience	Climate resilience is the capacity of social, economic and ecosystems to cope with a hazardous event or trend or disturbance caused by climate change
Coastal Cell Area	A spatial model which subdivides the coast based on the variation in physical characteristics, including the geology, geomorphology, shoreline topography and orientation, and existing defence type
Coastal erosion	Loss or displacement of land, or long-term removal of rocks and sediment along the coastline due natural impact of waves, wind, rain and tides
Coastal flooding	Submergence of normally dry and low-lying land by seawater
Coastal protection	Measures aimed at protecting the coast, assets and inhabitants from coastal flooding and erosion. Coastal protection may involve structural, non-structural or nature-based solutions
Coastal spit	A coastal landform, whereby a stretch of beach material projects out to the sea and is connected to the mainland at one end
Concept level design	Foundational phase of the design process which lays the groundwork for the entire project. The design work undertaken for the concept design is sufficient to confirm that the options will work from a technical perspective and will meet the Project objectives.
Concrete armour	Precast concrete units placed to form breakwaters or revetments to dissipate wave energy
Constructability	Also known as buildability. The extent to which a design facilitates the each and efficiency of construction

Design horizon	The period of time over which the scheme provides the required Standard of Protection (SoP) to the railway line
Design life	The service life intended by the designer, which is the period of time after installation during which the structure meets or exceeds the performance requirements
Dilapidation survey	A detailed survey that examines the existing state of the coastal structure
Dune regeneration	Stabilisation and enhancement of existing dune systems to deliver additional resilience
Embankment	Linear grassed earth structure providing flood protection; typically used along riverbanks
Emergency works	Works in response to an event that is unexpected and serious such that it presents a significant risk to human life, health and property or the natural environment and involves the need for immediate action to manage the risk
Feasibility study	An assessment of the practicality of a proposed project plan or method.
Flood proofing	Structural, and non-structural, solutions that can prevent or reduce flood damages to a property or its content.
Flood warning and preparedness	Measures undertaken to better prepare, respond and cope with the immediate aftermath of a flood event
Foreshore	The part of a shore between high- and low-water marks
Freeze-thaw weathering	Form of mechanical weathering whereby water enters cracks in rocks, freezes and expands, widening the cracks. Repetition of this cycle causes gradual break down of the rock.
Gabions	A basket or container filled with earth, stones, or other material
Geomorphology	The interaction between Earth's natural landforms, processes and materials
Geotextile	Permeable fabrics which, when used in association with soil, have the ability to separate, filter, reinforce, protect, or drain
Geotubes/ Geotextile Tubes	Tube shaped bags made of porous, weather-resistant geotextile and filled with sand slurry, to form artificial coastal structures such as breakwaters or levees
Groyne	Linear structure constructed perpendicular to the shoreline which helps retain beach material in place.
High tide mark	A point that represents the maximum rise of a body of water over land
Hydrodynamic modelling	Used in the analysis of coastal hydrodynamic processes, it is employed to simulate major physical phenomena in the coastal region
Maintenance burden	The level of maintenance (repair, monitoring, rebuilding) required over the design life of the structure to retain the Standard of Protection of the coastal defence structure
Managed realignment	A coastal management strategy that involves setting back the line of actively maintained defences to a new line inland and creating inter-tidal habitat between the old and new defences
Mudslides	Mass of typically saturated mud and earth debris that moves downslope
Multi criteria analysis	A structured approach to determine overall preferences among alternative options, where the options should accomplish multiple objectives.
Nature-based solutions	The use of natural materials and processes to reduce erosion and flood risk to coastal infrastructure
Pore water pressure	The pressure of groundwater help within a soil or rock in the gaps between particles
Residual risk	The degree of exposure to a potential hazard that cannot be completely eliminated
Revetment	Sloping or stepped structure built parallel along the shoreline between the low lying beach and higher mainland to protect the coast from erosion and wave overtopping. The revetment may have a smooth or rough surface

Rock netting	A drapery system designed to control rockfall movement by guiding falling debris to a collection point at the toe of the slope
Saltmarsh	Coastal grassland that is regularly flooded by seawater
Sea level rise	An increase in the level of the oceans due to the effects of climate change
Seagrass bed	Intertidal or sub-tidal beds of sea grass. Provides ecosystem benefits including carbon sequestration.
Seawall	Vertical or near-vertical impermeable structure designed to withstand high wave forces and protect the coast from erosion and/or flooding
Shellfish reefs	Sub-tidal or intertidal reefs formed of suitable material for settlement by oysters or mussels.
Sill	A low rock structure in front of existing eroding banks to retain sediment behind.
Standard of Protection	The expected frequency or chance of an event of a certain size occurring. Defined for this Project as being a 0.5% Annual Exceedance Probability, also known as a 1 in 200 year storm protection level.
Storm surge	A change in sea level that is caused by a storm event, which can lead to coastal flooding
Toe scour	Occurs when the toe (bottom) of the defence is worn away by the waves and can cause defences to fail.
Unconsolidated glacial till	Unstratified and unsorted debris ranging in size, derived from the erosion and entrainment of rock by glacial ice
Wave exposure	The degree to which a coast is exposed to wave energy
Wave overtopping	The average quantity of water that is discharged per linear meter by waves over a protection structure (e.g., breakwater) whose crest is higher than the still water level

Appendix A. Planning and Environmental Constraints Report

Document Number	Document Title
7694-XX-P2-FEA-EV-JAC-0001	PLANNING AND ENVIRONMENTAL CONSTRAINTS REPORT

Appendix B. Photographic Record

Figure 1 – CCA6.1-A: The sub-cell is a 1km long shingle beach, located at the front of Greystones station. The beach is 100m wide beach and has varying height levels depending on storm conditions. Vegetated embankments and concrete retaining walls are located at the back of the beach.

Figure 2 – CCA6.1-B: The sub-cell is a 2km steep rock revetment with concrete blocks at the back, located at the front of the local golf course. The railway here is located closer to the sea than in CCA6.1-A, resulting in more intense wave action. The rock is relatively large but has a broad variation in grading.

Figure 3 – CCA6.1-B: The rest of the sub-cell is also protected by a rock revetment and concrete blocks at the back. In this section, the rock used is of a smaller grading and is regularly displaced by wave action. The clearance between the sea and the track is large here, providing some additional protection to the railway.

Figure 4 – CCA6.1-C: The sub-cell is a 1.8 km long section with rock revetment and concrete blocks at the back, located at the front of Kilcoole station. A relatively narrow and steep shingle beach is present in front of the revetment.

Figure 5 – CCA6.1-D: The sub-cell here has a 60m wide sand-shingle mix beach, with low vegetation at the back of the beach. Evidence of local erosion due to wave action is visible, highlighting the increasing impact of storms on the beach.

Figure 6 – CCA6.1-D: The separation between sub-cells CCA6.1-D and CCA6.1-E is located at Kilcoole Estuary, also known as 'The Breaches'. The beach is very dynamic and the position of the estuary channel is known to fluctuate. The railway crosses the estuary over a bridge, the abutments are protected from erosion by boulders.

Figure 7 – CCA6.1-E: The rest of the cell is protected by a 40m wide sand and shingle beach, located between Kilcoole Estuary and Newcastle Airport. At the back of the beach, a narrow strip of vegetation is present with concrete blocks interspersed throughout. Beach levels remain stable in this area.

Appendix C. Options Assessment Supporting Modelling Outputs

Document Number	Document Title
7694-CCA6_1-P2-MMO-CM-JAC-0001	OPTIONS ASSESSMENT SUPPORTING MODELLING OUTPUTS CCA6.1

Appendix D. Short List Multi-Criteria Analysis Tables

Document Number	Document Title
7694-CCA6_1-P2-ENG-CV-JAC-0002	Short List Multi-Criteria Analysis Table CCA6.1

Appendix E. Option Concept Design Drawings

Document Number	Document Title
7694-CCA6.1-P2-DWG-CV-JAC-0001	CONCEPT DESIGN CCA 6.1 SITE LOCATION PLAN
7694-CCA6.1-P2-DWG-CV-JAC-0100	CONCEPT DESIGN CCA 6.1 OPTION A PLAN
7694-CCA6.1-P2-DWG-CV-JAC-0101	CONCEPT DESIGN CCA 6.1 OPTION B PLAN
7694-CCA6.1-P2-DWG-CV-JAC-0200	CCA6.1-A CROSS SECTIONS OPTION A
7694-CCA6.1-P2-DWG-CV-JAC-0201	CCA6.1-B AND C CROSS SECTIONS OPTIONS A & B
7694-CCA6.1-P2-DWG-CV-JAC-0202	CCA6.1 D CROSS SECTION OPTION A
7694-CCA6.1-P2-DWG-CV-JAC-0203	CCA6.1 D CROSS SECTIONS OPTION B
7694-CCA6.1-P2-DWG-CV-JAC-0204	CCA6.1-E CROSS SECTIONS OPTIONS A & B

Appendix F. Works Priorities Drawing

Document Number	Document Title
7694-CCA6_1-P2-DWG-CV-JAC-0300	CCA 6.1 COASTAL DEFENCE WORKS PRIORITIES

Appendix G. Implementation Options Multi-Criteria Analysis Tables

Document Number	Document Title
7694-CCA6_1-P2-ENG-CV-JAC-0003	Implementation Options Multi-Criteria Analysis Table CCA6.1

Appendix H. Scheme Concept Design Drawings

Document Number	Document Title
7694-CCA6_1-P2-DWG-CV-JAC-0400	CCA 6.1 CONCEPT DESIGN PLAN
7694-CCA6_1-P2-DWG-CV-JAC-0410	CCA6.1-D CONCEPT DESIGN CROSS SECTIONS
7694-CCA6_1-P2-DWG-CV-JAC-0411	CCA6.1-E1 & E2 CONCEPT DESIGN CROSS SECTIONS
7694-CCA6_1-P2-DWG-CV-JAC-0412	CCA6.1-E3, E4 & E5 CONCEPT DESIGN CROSS SECTIONS

Appendix I. Consultation Report

To be added following Public Consultation 1.